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THE PROTECTION OF HAWKS AND OWLS IN OHIO.*

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INTRODUCTION.

Among the changes in the world, brought about by the rapid development of methods and ease of communication during the last thirty years, may be seen the entire change of attitude of the farming population toward scientific agriculture. The farmer is no longer inaccessible, lagging behind and lacking in knowledge and news of the day, no longer farming by tradition and the turn of the moon as in the days which some of the eldest of us recall. The Federal and State Biological Surveys, State Colleges, and Experiment Stations have studied into every phase of scientific and practical agriculture, and the farmer, the progressive of today, has learned to accept and apply this information in daily life.

One of the last, but by no means least important, of the questions to receive careful study, and deserving immediate action, is this subject of the protection of our hawks and owls from wanton slaughter. All during our early days we recall how the cry of "hawk" on the farm meant always "chicken hawk" and all hawks were considered "chicken hawks" and, of course, we would run for the gun to destroy the invader.

It was the day of hear-say and tradition, and few of us ever thought to watch the hawk to see what he picked up when undisturbed, and discover that he came not always for the chickens, but frequently for the rats that were killing our chickens.

Of recent years the Federal and State bureaus have diligently gone after the facts in the case, by the examination of stomachs

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of thousands of birds and by other forms of accurate observation, and the results of these studies we have attempted to gather in this paper.

We do this in the belief that the progressive farmer will no longer allow the destruction of these useful birds, and that intelligent sportsmen and game keepers will realize that these birds, as they come over the line, are not necessarily after the game, but come to free the estate of the greatest enemies of game—the rats, mice, and other rodents.

A most interesting example of change in attitude of a population over a great area occurred in Southern Georgia, where our laboratory operated an experiment station at Thomasville for ten years. Between and about Thomasville and Tallahassee are two hundred thousand acres, divided into large plantations, many of them ten thousand acres or more, owned chiefly for game shooting. Delightful in winter climate, a land which cannot compete with the intensive agriculture of other states, but rolling, open fields, with much waste land of some hard wood and some pine, largely fields of thickets and weeds, it is ideal for game shooting which is the chief business of the region.

In 1923 the sportsmen of this region formed a committee, which was called the Cooperative Quail Investigation, and by private subscription raised funds for a five-year study, which was operated by the U. S. Biological Survey with Herbert L. Stoddard in charge.

The sportsmen have published a most complete and able report of this work in "The Bob-White Quail," by Herbert L. Stoddard, offered by Charles Scribner Sons, New York, 1931.

Mr. Stoddard, already an able field naturalist, devoted five years to the study of quail with not only his scientific assistants working upon all phases of life of the bird, but with the hearty cooperation and active assistance of all the owners and game keepers in that great game territory.

That he is now recognized and retained by the sportsmen of the South and East as an able consultant expert justifies our quoting him as to the supposed harm of hawks and owls. Quoting as to certain hawks:

Sparrow Hawk:

"No instance of attack on bob-whites by the sparrow hawk (*Falco sparverius*) came to the attention of the Investigation. . . . In several instances individuals took up quarters temporarily on the fence

posts of propagating enclosures and made forays against the large grasshoppers on the ground beneath, without harming the quail chicks in the least."

Red-tailed Hawk:

"Unless red-tails are unusually numerous they may well be tolerated upon quail preserves because of their usefulness in catching cotton rats and other destructive rodents, and because they eat some snakes, which are the most difficult of quail enemies for man to control."

Red-shouldered Hawk:

"Time devoted to killing these useful birds on the quail preserves is worse than merely wasted, for no instances of quail destruction on their part came to light during the course of the investigation."

Broad-winged Hawk:

"This is one of the wholly beneficial species that should be given full protection at all times. Unfortunately it is so tame and unsuspicious that many are shot under the guise of protecting game or poultry."

Marsh Hawk:

"In view of the fact that not more than four quail were discovered in approximately 1,100 pellets, marsh hawks can hardly be accused of making serious inroads on the number of quail in a region. On the other hand, one or more cotton rats were found in 925 of these pellets. . . . Since cotton rats destroy the eggs of quail, the marsh hawk is probably the best benefactor the quail has in the area, for it is actively engaged in reducing the number of these rodents."

Cooper's Hawk and Sharp-shinned Hawk:

These two are indeed bad actors, both being bird killers and destructive to either birds or game, and Mr. Stoddard advises local control of them. But any attempt at control of these two species must be in the hands of really well informed persons, for, again quoting Stoddard:

"While the majority of hunters and outdoor people probably can tell the fully adult Cooper's and red-shouldered hawks apart, few can differentiate them in their juvenal plumages."

Fortunately in Ohio these two comprise less than eight percent of the hawks found in the State.

Passing now to the report of Stoddard as to owls:

"In view of the fact that the first two species (great horned owl and barred owl) are valuable in keeping skunks, opossums, and rodent enemies of the bob-white within bounds and that all are great enemies of the cotton rats . . . all owls should be regarded as beneficial on quail preserves."

"One of the most discouraging sights seen by us during the Quail Investigation was a beautiful barn owl, hanging by one foot from a steel trap on a quail preserve where cotton rats were abundant. The services of this bird would have been highly valuable to the owner, but its life had been sacrificed by the indiscriminate pole trap, which has no place on a well managed quail preserve."

That we have given so much space to these quotations from the quail fields of Georgia is because these are not the arguments of the so-called "sentimentalists," but the report forms the practical working basis of a great body of sportsmen throughout the southern and eastern states.

It is of interest in this connection to go back seventy-three years to quote John Kirkpatrick writing in the *Ohio Farmer* in 1859, on "The Rapacious Birds of Ohio," as follows:

"Nature is nicely balanced in all her relations and man's interference often does more harm than good. It becomes necessary to weigh judiciously the ultimate consequences of our actions or we may find evil effects when good only were expected."

RODENT PESTS AND CATS.

In many parts of the country it has occurred that the immediate result of the general destruction of hawks is a tremendous increase of rats and mice and other rodents, creatures which are vastly more destructive to birds of all kinds, whether game or song birds, than hawks can be.

With the increase of rodents in fields and homes encouragement is given to the increase of cats, until both song and game birds become victims of the cat pest added to the destruction already caused by the rodents. Both pests do far more damage than could possibly be caused by even the worst of hawks or owls. The Sacred Cat has already the advantage of the seemingly universal superstition that it is unlucky to kill a cat. Because of this superstition the people living in cities and towns, instead of destroying the multitude of surplus kittens, pack them into bags and baskets and drop them promiscuously over the country.

This superstition alone may well account for some of the scarcity of birds and game, instead of blaming it upon the hawks and owls.

ESTHETIC AND CULTURAL IMPORTANCE.

The hawks and owls are of considerable esthetic and recreational importance. An ever increasingly interested public is taking to enjoyments and pleasures out-of-doors in the observance and study of nature. If predatory birds were missing from nature, a very great loss to this group of people would result, as the hawks and owls, because of their size, majestic flight, or conspicuousness, are always of profound interest.

A movement has been on foot for several years to set aside parks and sanctuaries all over the country for the conservation of wild life. It is very desirable on these areas to conserve all the wild life, hawks and owls as well as the rest, so as to leave nature as little disturbed as possible. Nature may be best appreciated and enjoyed by man when it is in as nearly as possible an undisturbed condition. One of the purposes of these areas is to furnish cultural centers to teach man to enjoy to a large degree the natural and undefiled out-of-doors. However, such areas are not always easily accessible to everyone. It is desirable that this conservation be supplemented nearer home. The conservation of the hawks and owls would be one item in such a program.

ABUNDANCE OF HAWKS IN OHIO.

Before ascertaining the food habits of the various species of hawks and owls, it is necessary to consider their abundance in Ohio. This is necessary for any satisfactory judgment of their economic importance. In order to determine the abundance of the various species, resource was had to correspondence with thirty-six ornithologists in the State. A request was made of each observer to compile the number of times he had observed each species each year and then to total the entire number of times he had observed each species for all the years of his observation. Data were also obtained on the number of trips taken by each observer, the number of hours spent in observation, and the total mileage covered.

Twenty people replied to these requests with data and notes. Their names are listed below with the counties in which they made their observations.

MILTON B. TRAUTMAN—All counties in State, particularly Fairfield, Licking, Pickaway, Perry, Franklin, Ottawa and Pike, 1922–1932.

Lawrence E. Hicks—All counties of State, 1918–1931.
S. V. Wharram—Ashtabula County, 1921–1931.
Cleveland Bird Club—Geauga, Lake, Cuyahoga, Lorain, Erie and Ottawa Counties, 1931.
John W. Aldrich—Notes.
S. Charles Kendeigh—Lorain, Erie, Ottawa Counties, 1920–1930.
Louis W. Campbell—Lucas County, 1926–1931.
Jim A. Bruce—Wayne County, 1928–1931.
Edwin Lincoln Moseley—Notes.
Paul A. Stewart—Columbiana and Mahoning Counties, 1927–1931.
Merit B. Skaggs—Trumbull and Mahoning Counties, 1922–1932.
Wm. C. Baker—Columbiana and Mahoning Counties, 1929–1932.
E. V. Prior—Licking County, 1927–1932.
R. B. Gordon—Franklin County, 1921–1930.
Margaret M. Nice—Franklin County, 1928–1931.
Floyd B. Chapman—Franklin, Fairfield, Licking, Hocking, and Delaware Counties, 1924–1932.
Paul Forsthoefel—Mercer County, 1925–1932.
Ben J. Blincoe—Montgomery, Green and Miami Counties, 1923–1931.
Wm. C. Herman—Notes.
Conrad Roth—Scioto and Adams Counties, 1926–1931.

The southern and southeastern parts of the State are not so well covered as the rest, but since two observers have studied in all the counties in the State while the other observers are fairly well scattered over the State, one is justified in believing that the relative abundance of the species, as given below, is representative.

A compilation of all the records sent in by the observers was made. These records are from seventeen observers covering the years 1918 to 1932. The total number of trips after birds taken by these ornithologists during this period was 6,902; the total number of hours spent in the field in observation was 39,095; while the total mileage covered was 180,142. The size of these totals is impressive, and since they were made by the best trained people in the state for the careful and exact identification of birds, they have considerable value.

In Table I, the number of times which each species of hawk was observed and its relative abundance are expressed.

Almost exactly half of all the hawks observed were sparrow hawks. This species was by far the most common one. The marsh hawk ranks next, followed by the red-shouldered and red-tailed hawks. These species are all decidedly beneficial to the farmer and sportsman. From the economic standpoint, more complaints have been lodged against the Cooper's, sharp-shinned, pigeon, duck, and goshawks than against any of the

others. Yet these five species together make up only 8.7% of the entire hawk population in the State. The other 91.3% of the hawk population is made up of species generally recognized by scientists to be beneficial. In other words, there are in the state of Ohio, over ten recognized beneficial hawks to every one that may be considered less desirable. The good done by the ten overbalances by far the harm done by the one, and gives a clear indication of the great economic importance of hawks to the farmer and sportsman in Ohio.

TABLE I.

RELATIVE ABUNDANCE OF HAWKS IN OHIO.

Species	Number of Times Recorded	Percent of Total Number Hawks Recorded
1. Sparrow Hawk	10,913	50.5%
2. Marsh Hawk	3,918	18.2
3. Red-tailed Hawk	1,946	9.0
4. Red-shouldered Hawk	1,640	7.6
5. Cooper's Hawk	1,168	5.4
6. Sharp-shinned Hawk	498	2.3
7. Broad-winged Hawk	369	1.7
8. Osprey	351	1.6
9. Bald Eagle	351	1.6
10. Rough-legged Hawk	272	1.3
11. Pigeon Hawk	86	0.4
12. Duck Hawk	57	0.3
13. Goshawk	32	0.1
14. Golden Eagle	5	0.02
Total	21,606	

ABUNDANCE OF VULTURES IN OHIO.

The turkey vulture and black vulture are sometimes mistaken for hawks by the uninformed. Both species are scavengers, living chiefly on dead and decaying matter, and so are of no harm to either the farmer or sportsman.

On the basis of the bird census described above, 25,703 turkey vultures and 357 black vultures were reported for the same period of time and over the same territory as were the hawks observed. The combined total of all species of hawks observed was 21,606, which is more than four thousand *less* than the number of times that the turkey vulture alone was observed. This beneficial species is a very important one, therefore, in a consideration of the bird life of Ohio. The black

vulture is far less common and confined entirely to the southern part of the State. The turkey vulture is also more common southward although generally distributed over the State.

ABUNDANCE OF OWLS IN OHIO.

Owls are much more difficult to locate and observe than are the hawks and vultures. In the census reports from seventeen observers which was described above, a combined total for all species amounting to only 3,585 individuals was observed, (Table II).

TABLE II.

RELATIVE ABUNDANCE OF OWLS IN OHIO.

Species	Number of Times Recorded	Percent of Total Number Owls Recorded
1. Screech Owl	1,672	46.6%
2. Barn Owl	558	15.5
3. Great Horned Owl	517	14.4
4. Barred Owl	450	12.6
5. Short-eared Owl	284	7.9
6. Long-eared Owl	52	1.5
7. Snowy Owl	28	0.8
8. Saw-whet Owl	24	0.7
Total	3,585	

The screech owl is by far the most abundant, the barn owl comes next, then the great horned owl and barred owl. The great horned owl which is sometimes destructive to poultry and game animals makes up only 14.4% of the total owl population. The other species are generally to be rated beneficial. Their combined total amounts to 85.6%. Thus, there are nearly six beneficial owls to each one that may sometimes be destructive. The economic status of the general owl population must be rated high.

FOOD HABITS.

Considerable study has been made by the Biological Survey, Department of Agriculture, Washington, D. C., and others, of the food habits of the various species of hawks and owls in the United States. Only when one knows the kind of food upon which the various species of hawks and owls feed, can one properly judge their exact economic importance. An attempt

has been made to summarize the available information on the nature of the stomach contents of all the species of hawks and owls that occur in Ohio, (Warren, 1890; Fisher, 1893).

TABLE III.

TYPES OF FOOD CONSUMED BY VARIOUS SPECIES OF HAWKS AND OWLS.

TURKEY VULTURE AND BLACK VULTURE.

Henderson (1927) states that these species feed chiefly on carrion. The turkey vulture also takes some snakes, toads, rats, mice, and occasionally young birds.

MARSH HAWK.

Stomachs examined—144.

Mice and other small mammals	54.9%
Small birds	23.6
Insects	9.7
Reptiles and batrachians	6.2
Poultry and game birds	4.9
Indeterminate	0.7

SHARP-SHINNED HAWK.

Stomachs examined—116.

Small birds	85.3%
Poultry and game birds	5.2
Mice and other small mammals	5.2
Insects	4.3

COOPER'S HAWK.

Stomachs examined—103.

Small birds	50.5%
Poultry and game birds	33.0
Mice and other small mammals	10.7
Lizards	2.9
Insects	1.9
Frogs	0.1

GOSHAWK.

Stomachs examined—25.

Mice and other small mammals	40.0%
Poultry and game birds	36.0
Insects	12.0
Small birds	8.0
Centipeds	4.0

RED-SHOULDERED HAWK.

Stomachs examined—398.

Mice and other small mammals	47.5%
Insects	23.1
Reptiles and batrachians	17.6
Spiders	4.0
Small birds	3.0
Crayfish	1.7
Fish	1.5
Poultry and game birds	0.7
Offal	0.5
Earthworms	0.2

RED-TAILED HAWK.

Stomachs examined—792.

Mice and other small mammals	69.6%
Poultry and game birds	9.0
Small birds	7.2
Insects	5.9
Reptiles and batrachians	5.0
Offal	0.2
Crayfish	0.1

BROAD-WINGED HAWK.

Stomachs examined—102.

Mice and other small mammals	31.4%
Insects	29.4
Reptiles and batrachians	27.4
Small birds	4.9
Crayfish	4.9
Earthworms	2.0

ROUGH-LEGGED HAWK.

Stomachs examined—58.

Mice and other small mammals	96.5%
Insects	1.7
Reptiles and batrachians	1.7

DUCK HAWK.

Stomachs examined—20.

Small birds	50.0%
Poultry and game birds	35.0
Insects	10.0
Mice and other small mammals	5.0

PIGEON HAWK.

Stomachs examined—61.

Small birds	67.2%
Insects	26.2
Mice and other small mammals	3.8
Poultry and game birds	3.8

GOLDEN EAGLE.

Stomachs examined—5.

Mice and other small mammals	40.0%
Carrion	40.0
Birds	20.0

BALD EAGLE.

Stomachs examined—17.

Fish	52.9%
Mice and other small mammals	29.4
Carrion	11.8
Game birds and poultry	5.9

TABLE III—[*Continued*]

TYPES OF FOOD CONSUMED BY VARIOUS SPECIES OF HAWKS AND OWLS.

SPARROW HAWK.

Stomachs examined—476.

Insects	50.2%
Mice and other small mammals	25.4
Small birds	13.0
Spiders	6.1
Reptiles and batrachians	2.5
Game birds	0.2

OSPREY.

Stomachs examined—11.

Fish	100.0%

BARN OWL.

Stomachs examined—47.

Mice and other small mammals	83.0%
Insects	8.5
Small birds	8.5

Pellets examined (*)

Number of skulls identified from Ohio—8,672

Mice and other small mammals	98.7%
Small birds	1.3

LONG-EARED OWL.

Stomachs examined—129.

Mice and other small mammals	86.0%
Small birds	11.6
Insects	1.6
Poultry and game birds	0.8

Pellets examined (†)

Number of skulls identified—88

Mice and other small mammals	95.7%
Small birds	4.3

GREAT HORNED OWL.

Stomachs Examined—134.

Mice and other small mammals	62.0%
Poultry and game birds	23.1
Insects	7.5
Small birds	6.0
Fish	0.7
Scorpions	0.7

SHORT-EARED OWL.

Stomachs examined—114.

Mice and other small mammals	83.3%
Small birds	10.5
Insects	6.1

BARRED OWL.

Stomachs examined—122.

Mice and other small mammals	56.5%
Insects	11.5
Small birds	11.5
Crayfish	7.4
Poultry and game birds	5.7
Frogs	3.3
Fish	1.6
Spiders	1.6
Lizards	0.8

SAW-WHET OWL.

Stomachs examined—26.

Mice and other small mammals	73.0%
Insects	23.1
Sparrows	3.8

SCREECH OWL.

Stomachs examined—300.

Mice and other small mammals	40.6%
Insects	34.0
Small birds	14.7
Crayfish	3.0
Miscellaneous	2.3
Reptiles and batrachians	2.0
Spiders	1.7
Scorpions	0.7
Earthworms	0.7
Fish	0.3

SNOWY OWL.

Stomachs examined—26.

Mice and other small mammals	64.5%
Small birds	29.0
Game birds and poultry	6.5

*Examinations by Roscoe W. Franks and Arthur Stupka.
†Examinations by the Wheaton Club, of Columbus, Ohio.

FOOD CONSUMPTION.

After considering the food habits of the different species of hawks and owls it is useful to summarize these data for all hawks together and all owls together. This furnishes a better criterion as to the actual amounts and kinds of food consumed by all birds of prey in Ohio, and enables us to judge better the

economic status of our hawk and owl population taken as a whole. These summaries are given in Tables IV and V.

The percentages in these two tables were arrived at in the following way. It was desirous to determine the percentage of each type of food in the total amount consumed by all hawks and by all owls in the State. In order to arrive at such figures, the relative abundance of each species (Tables I and II) had to be considered so that the types of food consumed by the more abundant species may carry proportionally more weight than the type of food consumed by the less common species. For instance, poultry and game birds make up 33.0% of the food of the Cooper's hawk, but the Cooper's hawk constitutes only 5.4% of the entire hawk population, so multiplying these two figures together and dividing by 100 gives 1.8% as the actual proportion of the entire food consumption of all hawks which this food habit of the Cooper's hawk represents.

Then again, mice and other small mammals make up only 25.4% of the food of the sparrow hawk. This is however, the most abundant hawk in the State (50.5%), so this food habit of this single species amounts to 12.8% of all the food consumed by all the hawks in the State. When these percentages are worked out for each type of food and for each species, the total combined results occur as given in the following two tables (IV and V).

TABLE IV.

Analysis of Total Food Consumption by All Hawks in Ohio.

Mice and other small mammals	35.7%
Insects	30.3
Small birds	16.9
Poultry and game birds	4.8
Reptiles and batrachians	4.8
Fish	2.6
Centipeds, offal, crayfish, spiders, scorpions, earthworms, and indeterminate	4.0

TABLE V.

Analysis of Total Food Consumption by All Owls in Ohio.

Mice and other small mammals	57.3%
Insects	20.4
Small birds	12.0
Poultry and game birds	4.1
Reptiles, amphibia, centipeds, crayfish, spiders, scorpions, earthworms, offal, fish, and miscellaneous	7.0

In looking over the records of stomach examinations for the various species in Table III, one may be inclined to conclude

that the Cooper's hawk, sharp-shinned hawk, goshawk, duck hawk, and pigeon hawk are very destructive predators, but when the food habits of the hawks, as a group, are studied with relation to their relative abundance, as in Table IV, we find that the amount of poultry and game birds eaten make up only a very small fraction (4.8%) of the diet. This fact is more sharply emphasized in the food studies of the owls. In this group the great horned owl does more damage than all the other species of owls combined, yet only 4.1% of the entire food of all the owls consists of game birds and poultry. We may charge up to the hawks and owls the 4.8% and 4.1% respectively of their diet taken from the supply of game birds and poultry, but we must also credit them with taking 66.0% and 77.7% respectively of their diet from our abundant supply of insects, mice, and other small rodents.

The insects eaten by the predaceous birds consist largely of grasshoppers and other large vegetarian forms and for this reason are placed on the credit side of the ledger of these birds.

The hawks and owls make up 16.9% and 12.0%, respectively, of their diet from small birds which are primarily seed and insect eating forms. This, in itself, is not of as great significance as may, at first, appear. The economic status of our smaller birds is not clearly known, because the relative value of the different kinds of food consumed is not well established. Do the insectivorous birds feed more on harmful forms of insects than on beneficial forms? Are they selective in their feeding habits? Do they avoid or destroy parasitic insects which are probably even more potent than are birds in holding the insect population in check? Undoubtedly, seed-eating birds consume immense numbers of weed seeds each year and act as one environmental agent in the balance of nature. However, are not natural competition among the weeds and plants themselves, together with climatic conditions, more potent factors in determining their abundance? Probably few of our small birds are entirely beneficial or entirely harmful in their food habits.

The food habits of some of the mice and other small rodents should be given careful consideration. If the feeding habits of these animals preyed upon by the predacious birds were wholly beneficial to man, then the birds of prey would be undesirable citizens. However, almost without exception, the

entire supply of food consumed by the mice and other small rodents is a direct loss to man. The field mice are abundant throughout the world and subsist upon field crops where they are available.

In the United States Department of Agriculture Year Book, 1917, we find the value of crops destroyed annually by rodents in the United States was estimated to be in excess of $150,000,000. This does not include the losses inflicted by house mice and common brown rats. In the same report we find the damage done in the State of Montana ran between fifteen and twenty million dollars, in Kansas twelve million, in North Dakota from six to nine million, and in California twenty million. In Wyoming, fifteen percent of all crops were destroyed by rodents. If the crops destroyed by rodents could be sold on the market, the return from this source would be sufficient to pay all the farmers' taxes.

Laboratory experiments by Bailey, 1924, reveal that the short-tailed field mice will eat on an average an amount per day equivalent to 107% of their own body weight when fed grass, clover, and cantaloupe rinds. Taking the average body weight of this species at thirty grams, Bailey figures that it will require 10,950 grams (23 pounds) of green food to feed each field mouse one year. He also states that 2,300 pounds of green grass or clover will produce one half ton of dry hay.

With these figures as a basis, we can arrive at the actual value of barn owls to agriculture. One pair of barn owls nesting in a sycamore tree came to the writers' attention February 13, 1927. Pelletts regurgitated in this tree were collected regularly over a period of two months time and their contents identified. During this time 518 mouse and shrew skulls and three sparrow skulls were left by the two owls. On this basis it would be conservative to say that one pair of barn owls will kill on an average 3,000 mice per year.

Using Bailey's figures for the amount of food consumed by field mice, we find three thousand mice would destroy 69,000 pounds of green feed per year, and that 69,000 pounds of green grass or clover is equivalent to 15 tons of dry hay. Assuming that one-half of this is of value to the farmer, the potential value of a single pair of barn owls is equivalent to 7½ tons of hay per year. Hay is worth on an average about $10.00 per ton. Therefore, the potential value of a pair of barn owls to agriculture is $75.00 per year.

Rodents are also among the worst pests with which the sportsman has to deal. Rodents destroy the eggs and young of game birds (Stoddard, 1931, p. 424).

The potential rate of reproduction of the field mouse is extremely high, and under favorable conditions the numbers may soon reach the state of a plague. Bailey's laboratory experiments clearly demonstrated this fact. He found that the first litter may come when the female is forty-five days old, and that the gestation period is twenty-one days. There are usually four young in the first litter, but six to eight in later ones. One female in captivity raised seventeen litters in one year, including 83 young, and remained in normal health. If all the progeny should live and reproduce at the same rate, one million individuals would be produced in one year. Under ordinary circumstances in a state of nature, the young do not all live. Nevertheless, when natural checks were removed, there have been many serious mouse plagues in this country and in many foreign countries.

CONTROL OF RODENT PLAGUES.

A brief review of some of the more serious rodent plagues in the United States and in Great Britain will serve to indicate the extreme importance of the predatory birds in keeping the numbers of the smaller mammals within bounds.

If the natural and normal checks against too rapid multiplication of rodents are removed, great damage results. As an example of what might happen in Ohio, due to killing off the predatory birds, the recent outbreak of the common house mouse, *Mus musculus*, in Kern County, California, in January, 1927, may be described (Hall, 1927).

"At the source, the dry bed of Buena Vista Lake, the writer found as many as 17 mice per square yard over an area of many acres in extent in the kafir corn field. Computed from the counts made on the measured areas, one arrives at the startling number of 82,280 mice per acre. This gives 2,668 pounds of mice per acre, figuring that $33\frac{1}{3}$ house mice weigh one pound.

"Grain bins that I saw had literally thousands swarming about in them; haystacks sheltered nearly as many; and the fields, since they had not been grazed by domestic stock, sheltered millions more. In one grain bin 20 feet square, that was two-thirds full of sacked barley, it was computed that 3,520 mice were in sight at one time. These were on the surface of the grain, on rafters, and on the pole plates. Many times this number unquestionably were out of sight in and among the sacks of grain. At night, on the highway that passes along the

north shore of Buena Vista Lake, the illumination from the headlights of one's car revealed hundreds of live mice at any given instant."

"Actual damage that the mice were seen to do included the destruction of quantities of stored grain; the reduction of large stacks of hay (really straw stacks that are here used for hay) to mere piles of chaff, thus rendering them totally unfit for stock food; the destruction of foodstuffs, clothing, bedding, linen, etc., in the houses; and the gnawing of holes through the floors and walls of frame buildings. It seems probable that the mice would damage growing crops although certainly not to the extent that equal numbers of meadow mice (*Microtus*) would. The house mice constitute a general nuisance on numerous counts. Many people have a general horror, on no specific grounds, of such vast hordes of mice. . . . Where large numbers of mice congregate, as in grain bins and haystacks, the stench arising from the voided body excrements is highly offensive and nauseates many persons. In one observed instance a laborer working at a haystack was so nauseated by the stench from the mice as to vomit severely. In buildings that are not mouse-proof, persons commonly have their sleep interrupted by the numbers of mice that run about over the bedding. On arising in the morning mice are not infrequently found in one's clothing and shoes. During the day, even, when going about ordinary tasks, mice on occasion enter one's clothing. All these things, together with the actual damage done by the mice, naturally have caused considerable concern among the people living in the infested area."

"Hawks, owls, and ravens were more abundant here than usual, due to a movement into the infested area. . . . Named in order of their abundance from first to last, the hawks noted were: Marsh Hawk (*Circus hudsonius*), Western Red-tailed Hawk (*Buteo borealis calurus*), Desert Sparrow Hawk (*Falco sparverius phalaena*), and a rough-legged hawk (*Archibuteo*, sp.?). Barn Owls (*Tyto pratincola*) were abundant, and Short-eared Owls (*Asio flammeus*) were seen wherever there was terrestrial cover, a condition that obtained only at the western end of the lake. . . . Ravens (*Corvus corax sinuatus*) were present in flocks of 15 to 40 and fed on the mice. . . . Although predatory birds were abundant, predatory mammals were extremely rare in the infested area."

Other severe mouse plagues have occurred in various regions. In 1907–08, in Humboldt Valley, Nevada, there was an outbreak of field mice (*Microtus montanus*) that did considerable damage (Piper, 1909). Here it was estimated that there were from 8,000 to 12,000 short-tailed field mice to each acre. The fields were riddled by their burrows which were scarcely a step apart and over a large area averaged 150 to 175 to the square rod. The Humboldt Valley is occupied by a number of large ranches. At the time the plague began there were about 20,000 acres in alfalfa. Within a year and a

half of that time more than 16,000 acres had been destroyed by the mice. This loss to the farmers in the one valley alone amounted to $300,000 in two seasons. This serious plague was finally checked by the natural enemies of the rodents and by poison.

The striking evidence of the valuable services of the natural enemies of mice seen during this plague is but an example of their constant value. Hawks, owls, gulls, crows, ravens, herons, and shrikes among the birds, and coons, coyotes, foxes, weasels, badgers, and wildcats among the mammals, habitually prey upon field mice and are most valuable in preventing undue increase of these pests. In the Nevada valleys all species of hawks and owls are distinctly beneficial, and their rigorous protection has been strongly advocated.

In the report of the 16th American Game Conference (1929) we find that there has been a bounty on owls and hawks in Virginia for twenty years, and along with the depletion of the birds of prey there has been a corresponding increase in pine and short-tailed field mice. These mice are now so abundant in the Virginia orchards and nurseries that they have become an irresistible scourge and each year are wiping out many fortunes and making orcharding impossible in that State. Quoting from Dr. A. K. Fisher, "They are paying out a large sum to protect a potential thousand dollars of game, and probably losing several millions of dollars worth of agriculture."

Mr. Max Hart, secretary of the Virginia Game and Fish Commission, while speaking before the last American Game Conference (1931) hit the keynote with reference to vermin control. Referring to Virginia, Mr. Hart says that in the past ten years we have spent $200,000 on vermin control, but we have just about reached the conclusion that we have got to take that money that we are paying for vermin and buy game birds with it, and put them back in the fields and stop paying bounties on birds of prey. With all of their campaigning against "vermin," the Virginians have learned that killing off hawks and owls will not bring back the game birds.

A perfect example of what constant trapping of all predatory birds and mammals will do by way of removing all checks on the increase of field mice, can be seen on our own State game farm at Wellington, Ohio. On this farm a rigid and extensive campaign of trapping and shooting hawks and

owls is maintained throughout the year without regard or knowledge of the species taken. The game keeper's report to the Division of Conservation made on January 15, 1930, reveals that from March 1, 1929, to the date of the report, 213 hawks and 171 owls were killed on the farm. It is not likely that this number of predatory birds was attracted to the game farm by the game birds that were there, but by the countless thousands of field mice, with which the farm was literally teeming. A walk across the fields revealed the most abundant supply of these rodents ever seen by the writers. Mice could be seen almost constantly as they ran from under foot.

The game keepers of Great Britain are responsible for practically exterminating the hawks and owls on the islands (Adair, 1893; Maxwell, 1893; Middleton, 1930). Due to the almost total absence of predatory animals, Great Britain's vole plagues have been gradually and rapidly increasing for the past thirty years. During 1929 there were eleven major plagues scattered throughout the Islands.

The good work of the hawks and owls in destroying insects, mice, and other small rodents does not consist of breaking up plagues of these forms after they are once beyond control, but by the prevention of plagues arising, by the killing of millions of individuals long before the plague stages begin to threaten.

Here in Ohio we can well afford to spare an occasional game bird or chicken, if need be, to prevent rodent plagues such as occur every four years in Great Britain.

CONTROL MEASURES.

The above information shows clearly that the general hawk and owl population in Ohio have beneficial food habits and are powerful agents in the natural control of rodents. It is not best to distinguish too closely between species, because they all exert some important, controlling influence in nature, and the average person is not able to identify the different forms nor able to properly judge between the beneficial and harmful species. It is rather best to pass judgment on the hawk population as a whole and the owl population as a whole and base our state control measures upon whole populations rather than on each species separately.

If a general campaign against all hawks and owls were undertaken, the average person unable to discriminate between

species would very probably destroy ten beneficial hawks to one harmful one, nearly six beneficial owls to one harmful one, and would probably destroy as many beneficial vultures (if he could come within gun range) as he would all the hawks and owls together. Since the hawk and owl population is predominantly beneficial, such a general campaign should be made legally impossible.

As an illustration of the type of results that are obtained when state-wide eradication is attempted of some species and not others, the recent experience of Pennsylvania in 1929 may be cited. A bounty law was passed providing $5.00 on all goshawks taken in the State. Within one year after the law went into effect, 503 birds were taken into the office of the Pennsylvania Game Commission at Harrisburg in order to secure the $5.00 bounty. Out of this 503 birds only 76, or 15%, were goshawks. Over 58% of all the birds taken were of beneficial varieties.

TABLE VI.

Species and Number of Individuals Killed in State-wide Eradication Campaign Against the Goshawk in Pennsylvania.

Red-tailed Hawk	165
Cooper's Hawk	120
Red-shouldered Hawk	84
Goshawk	76
Marsh Hawk	28
Sharp-shinned Hawk	9
Rough-legged Hawk	7
Sparrow Hawk	4
Broad-winged Hawk	3
Duck Hawk	3
Pigeon Hawk	1
Osprey	1
Short-eared Owl	1
Great Horned Owl	1

Several years ago when a hawk law was in force in Ohio, the township clerk at Wakeman issued 86 bounty certificates. Of these 86 hawks killed, 46, or 53.5%, were sparrow hawks, which is a very beneficial species (Fisher, 1907, p. 9). This is to be expected in indiscriminate shooting of hawks, since our census indicates that 50.5% of all hawks which one may meet in the field belong to this species. Such activities soon bring species on the verge of extinction, with the resulting dangers from rodent plagues. Control measures designed to eliminate certain species and not others are distinctly and unquestionably *inadvisable*.

Certain states, notably Pennsylvania, have undertaken in bygone times state-wide campaigns for the eradication of hawks and owls. The great economic loss which these campaigns have meant to the state is well summarized in the Report of the Commissioner of Agriculture for 1886 (Merriam, 1887):

"On the 23d of June, 1885, the legislature of Pennsylvania passed an act known as the 'scalp act,' ostensibly 'for the benefit of agriculture,' which provides a bounty of fifty cents each on Hawks, Owls, Weasels, and Minks killed within the limits of the State, and a fee of 20 cents to the notary or justice taking the affidavit.

"By virtue of the act about $90,000 has been paid in bounties during the year and a half that has elapsed since the law went into effect. This represents the destruction of at least 128,571 of the above mentioned animals, most of which were Hawks and Owls.

"Granting that five thousand chickens are killed annually in Pennsylvania by Hawks and Owls, and that they are worth 25 cents each (a liberal estimate in view of the fact that a large proportion of them are killed when very young), the total loss would be $1,250, and the poultry killed in a year and a half would be worth $1,875. Hence it appears that during the past eighteen months the State of Pennsylvania has expended $90,000 to save its farmers a loss of $1,875. But this estimate by no means represents the actual loss to the farmer and taxpayer of the State. It is within bounds to say that in the course of a year every Hawk and Owl destroys at least one thousand mice, or their equivalent in insects, and each mouse or its equivalent so destroyed would cause the farmer a loss of two cents per annum. Therefore, omitting all reference to the enormous increase in the numbers of these noxious animals when nature's means of holding them in check has been removed, the lowest possible estimate of the value to the farmer of each Hawk, Owl and Weasel would be $20 a year, or $30 in a year and a half."

"Hence in addition to the $90,000 actually expended by the State in destroying 128,571 of its benefactors, it has incurred a loss to its agricultural interests of at least $3,857,130, or a total loss of $3,947,130 in a year and a half, which is at the rate of $2,631,420 per annum! In other words, the State has thrown away $2,105 for every dollar saved! And even this does not represent fairly the full loss, for the slaughter of such a vast amount of predaceous birds and mammals is almost certain to be followed by a correspondingly enormous increase in the numbers of mice and insects formerly held in check by them, and it will take many years to restore the balance thus blindly destroyed through ignorance of the economic relations of our common birds and mammals."

It is conceivable that locally on game farms, in poultry yards, and similar places, a certain amount of protection against preying individuals of some species of hawks and owls may be necessary. Individual birds occasionally acquire

devastating habits, and their elimination is justified. One must make sure, however, that hawks visiting poultry yards are not after rats and mice rather than chickens. Such few individuals, however, by no means condemn the species as a whole nor warrant general campaigns of eradication.

In the protection of local areas, care must be taken in selecting the proper method of defense. Poisoned bait is not recommended because of the great danger to which it exposes other species.

Likewise, the pole-trap is distinctly not advised because it does not distinguish between individual birds bent on destruction from others. Wight (1931) discusses the use of pole-traps on state game refuges in Michigan and shows clearly that they are much more detrimental to beneficial species, including many of the smaller song birds, than they are to the few harmful species of hawks and owls.

Some other method should be used as a control measure. Probably the use of the shotgun on hawks and owls caught in the act of stealing is the safest and best method.

CONSERVATION MEASURES.

In 1928, Hadley reported on the legal status of hawks and owls in the United States at large. Thirty-four states at that time gave some protection to hawks and owls, usually discriminating between species that were sometimes harmful and those which were beneficial. In an attempt to determine how effectively these laws were enforced, Hadley sent a questionnaire to the game commissioners in each state. The general consensus of opinion was that these laws were unenforceable, particularly when it came to protecting some species and not others.

In view of the difficulty of the average person in distinguishing between the various species, a law giving protection to some species and not to others is impracticable and impossible to enforce. The solution is, of course, to create a law giving the same consideration to all species equally. If a study of all the hawks and owls over the State should show that they are predominantly harmful, no protection needs to be offered any species. If, on the other hand, such a study should show that they are predominately useful, then it is best to give equal protection to all. This study indicates strongly that the latter condition is the true one.

The conclusion is warranted, therefore, that the state legislature is amply justified, on the basis of scientific data available, to adopt a law giving rigid protection to all hawks and owls over the State. A clause may be inserted in such a law permitting special control against devastating hawks or owls in local regions, but eliminate, entirely, all possibility of general state-wide campaigns for destruction.

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Editor's Note.

It will be of interest to the readers of the above paper to note that the Ohio Academy of Science at its annual meeting in 1932 approved and accepted the following recommendation offered by the Committee on State Parks and Conservation:

"We believe that all persons interested in conservation of our wild life should rally to the support of our birds of prey. Due to popular prejudice resulting in indiscriminate persecution of all species, our birds of prey are rapidly decreasing in numbers, some species being threatened with extermination. The great majority of our predacious species have long since been proven to be beneficial in their food-habits, while the few species known to be more or less destructive are so reduced in numbers that any damage attributable to them is negligible.

We recommend that all birds of prey be protected by law, subject to the right of any citizen to control them when in the act of destroying his property.

We further believe that the pole-trap is a wasteful and inhuman means of capturing birds of prey, since it not only does not discriminate between injurious and beneficial species of predacious birds, but also destroys large numbers of song-birds and game mammals. We therefore recommend that legislation be enacted making use of the pole-trap illegal."

THE BLUE HOLE OF CASTALIA.

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INTRODUCTION.

The Blue Hole of Castalia, famed for its beauty and one of the scenic spots in Ohio, is located on the northern outskirts of the village of Castalia, seven miles southwest of Sandusky and about three miles from the Erie-Sandusky county line, which at one time marked the western boundary of the Connecticut Western Reserve.

The earliest historical record of the springs at Castalia is that in the report of Major Robert Rogers of New Hampshire.[1] After the fall of Quebec, Major Rogers left Montreal to take over the western forts held by the French and Indians. At Presque Isle he met Pontiac and was escorted to Detroit. Having secured the post at Detroit, Rogers returned by way of the Sandusky and Tuscarawas Trail which passed near the head of Cold Creek where the Castalia springs are located. In his observations of September 13, 1760, he remarks, "there is a remarkable spring at this place rising out of the side of a small hill with such force that it boils out of the ground in a column three feet high. I imagine it discharges ten hogsheads of water a minute."

This area was frequently occupied by the Ottawa and Wyandot Indians, the latter establishing a village on the present site of the town of Castalia. The springs furnished a plentiful supply of clear, cold water and Cold Creek leading from them, in its natural course, flooded much level land which was a paradise for muskrats, otter and mink. Deer and wild turkey were also numerous.

TOPOGRAPHY AND GLACIAL HISTORY.

In order that one may appreciate the geology of the area in which the Blue Hole is located, it is necessary to include the territory bounded by Sandusky Bay on the north, by

[1]Peeke, "History of Erie County," Lewis Publishing Company, Chicago, 1916.

parallel 41° 15′ north latitude on the south, and by meridians 82° 30′ and 83° W, essentially the area included within the Sandusky and Bellevue quadrangles.

The topography of this area, which lies wholly within the Erie Lake Plain of the central lowlands, is without any marked features. It is generally level and slopes gradually northward to Sandusky Bay which is considered the drowned pre-glacial channel of the Sandusky River. In pre-glacial time the Sandusky River flowed eastward past Johnson's Island to the trunk stream which is believed to have occupied the basin of Lake Erie and drained eastward from Detroit to Niagara.

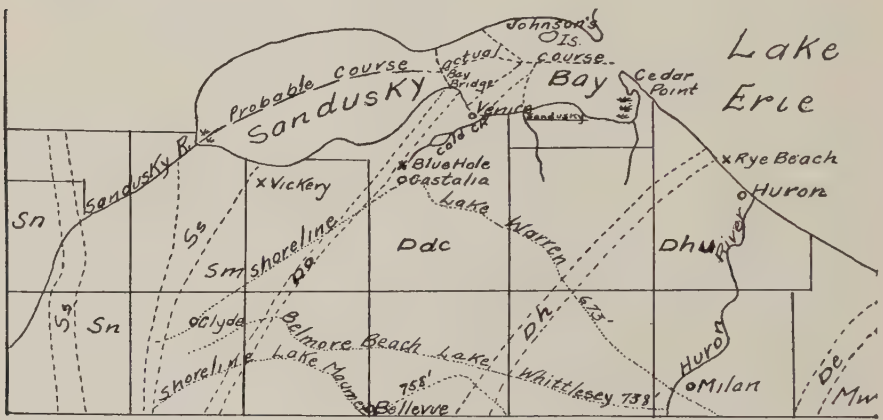

FIG. 1. Map of the Castalia area, showing formations, beach ridges and pre-glacial drainage. Legend: Niagara, Sn; Salina, Ss; Monroe, Sm; Oriskany, Do; Delaware and Columbus, Ddc; Hamilton, Dh; Huron, Dhu; Erie, De; Waverlyan, Mw.

Professor E. L. Mosely[2] has traced the course of the Sandusky River in the eastern half of the bay by means of auger drillings. Cold Creek, which obtains its supply of water from springs at Castalia now empties into Sandusky Bay at Venice, but originally continued in a northeasterly direction for two miles and joined Mill Creek which flowed into the old Sandusky River south of the western end of Johnson's Island.

South of Sandusky Bay the gently rolling, monotonous topography, characteristic of the prairie regions, has been produced by the planing action of glaciation and the expanded

[2]Mosely, E. L., "Formation of Sandusky Bay and Cedar Point," Ohio State Academy of Science, Vol. IV, Part V.

post-glacial lakes of Pleistocene time. As a result of glaciation, drift deposits of clay covered the region but these were largely removed by the post-glacial lakes. The withdrawal of the lake resulted in a fine, rich soil which is now covered by grass and sparsely timbered. The Castalia Blue Hole area is about one hundred and eighty feet above the level of Lake Erie, toward which consequent drainage is effected by numerous surface streams and the Huron River to the east. The absence of surface drainage is very noticeable in the limestone sink area, extending southwest of Castalia.

The history of the shrinking post-glacial lakes is readily determined by the old Lake beaches that roughly parallel the present Lake Erie from west to east. The first lake formed in the northeastward retreat of the Wisconsin glacier was Lake Maumee whose outlet was located at Fort Wayne, Indiana, through the Wabash and Mississippi rivers. This was the highest and oldest lake formed by the impounding of glacial water in front of the Labradorian ice sheet. The Maumee beach may be seen in the western part of Bellevue and the southeastern portion of Norwalk. It follows approximately the 750′ contour line and extends from the southeast corner of the area, three miles south of Clyde, through Bellevue and Norfolk. The next lowest beach parallels that of Lake Maumee at an altitude of about 738′ above sea level, one hundred and sixty-five feet higher than Lake Erie. The third and last beach in this area is that of Lake Warren, a lake of great size, the outlet of which was by way of Ubly, Michigan, Lake Chicago and the Illinois River. This beach is quite distinct and serves as the route for the Clyde-Castalia road or State Highway 101. It extends from Clyde in a northeasterly direction, a distance of fourteen miles to a point beyond Castalia, where it bends to the southeast toward Milan and Berlin Heights, parallel to the present shore of Lake Erie. Between the Lake Warren beach, one hundred feet above Lake Erie, northward to the shore of Sandusky Bay, the topography is flat and gently sloping. Castalia lies at the base of a limestone promontory that extended into the waters of Lake Warren. This position, at the base of a limestone drainage area to the south, is responsible for the outlet of the springs at Castalia and elsewhere to the west, such as the Rockwell Springs.

STRUCTURE.

Castalia is located on the Columbus limestone of Middle Devonian age which is underlain by the Monroe limestone of the Upper Silurian. All the formations of the area dip to the southeast at a low angle. Castalia stands on the eastern flank of the Cincinnati arch or geoanticline, near the axis, which bends to the east across Lake Erie into Ontario. In consequence of this dip the rock outcrops in Ohio are roughly arranged in north and south bands across the state. The rock outcrops in the Castalia area extend in a southwest-northeast direction, due to the curve of the axis of the Cincinnati arch. Early Waverlyan, or Lower Mississippian sediments appear on the east, followed by the Ohio shales of the Upper Devonian which are more than three hundred feet thick. Sandusky and Castalia are located on the Onandaga (Columbus and Delaware) limestone of Middle Devonian age which is underlain by the Monroe limestone of Upper Silurian (Cayugan) age. The Monroe limestone is a typical dolomite about one hundred feet thick and it is in this horizon as well as the Columbus and Delaware formations that the underground streams in the region about Castalia have carried on their work. The Cincinnati arch flattens out at its crest in western Ohio, in consequence of which the Monroe formation outcrops extensively. It is in this formation that the caves of west-central Ohio, at West Liberty and Zane were formed. Sink-hole topography is best developed in the Bellevue-Castalia area.

GENERAL DISCUSSION.

Caves and sink holes are characteristic of a limestone region. Prominent cave and sink-hole areas in the United States occur in north-central Florida, Virginia, and central Kentucky. The celebrated Mammoth Cave and the Luray Cave are large scale examples of the same processes which formed the underground passages near Castalia and the caves of Put-in-Bay, Ohio. The surface water with the aid of carbon dioxide and organic acids in solution, dissolves the limestone along every crack it penetrates and forms a connecting system of underground channels by which all drainage of the region is effected. In limestone areas streams may disappear beneath the surface and after flowing underground for great distances reappear, issuing forth as a stream or a

huge spring. Similar fountains occur in foreign countries, notably Greece where the classical Clitumnus burst forth at the base of a limestone mountain. This spring was famous for its cerulean blue water and was sacred to Apollo and the Muses.

A glance at the Sandusky and Bellevue topographic maps discloses the extensive development of underground drainage which has undermined the Columbus and Delaware limestone, causing it to slump into the cavities below, forming sink-holes. These are depressions with no outward drainage and surrounded by inward facing cliffs, formed when the roofs of the caves collapse. Perhaps the largest and most typical example in this area is located a mile south and east of Castalia, where a sink-hole includes several acres without surface inlet and faced by cliffs of rock still in their original position.

The sink-holes are concentrated south and southwest of Castalia toward Bellevue, nine miles to the south, and Clyde twelve miles to the southwest. The Silurian-Devonian contact (Monroe-Columbus) cuts diagonally across the Bellevue quadrangle from Bay Bridge on Sandusky Bay to the southwest corner of the Bellevue quadrangle, passing about a mile and a half east of Clyde. The Upper Devonian-Middle Devonian (Huron-Columbus) contact describes an arc from a point about two miles southeast of Bellevue to Rye Beach on Lake Erie. Between these limits is the outcrop of Delaware and Columbus limestone and the area of sink-hole distribution. Sink-holes do not appear on the Monroe outcrops to the west but numerous springs issue forth; those at Vickery are examples. To the south in Ohio, along the Silurian-Devonian contact, the writer did not find any sink-hole development comparable to that in the Bellevue quadrangle. The number of sinks decreases rapidly in Seneca County on the south but are numerous north and west of Bellevue. This city is known for its lack of a sewer system. The amount of sewer pipe is almost negligible, for all the inhabitants need to do is to drill a hole of sufficient depth in the Delaware and Columbus limestone through which all the sewage escapes and is carried away through subterranean channels. The popular concensus of opinion is that the outlet is unknown, that the source of the Blue Hole water has not been determined, and that the depth of the vivid blue water is limitless. Mosely introduced corks and cork dust into the sinks at Bellevue. These were looked

for by the residents of Castalia, but never found; they were doubtless filtered out as is most solid matter in ground water. Nevertheless, since the watershed slopes from Bellevue north to Sandusky Bay, the water coming from the springs in Castalia must obviously come from the south, according to geologic reasoning. During the heavy rainfall of the spring of 1913 which occasioned the Sandusky River floods, the amount of run-off was so great that the channels draining the Castalia-Bellevue area were filled beyond their capacity, resulting in the flooding of low places in Bellevue and the fields to the north by water which came forth from openings where normally it entered. In the spring of 1930 many acres were flooded and the Castalia-Bellevue road, four miles north of Bellevue was impassible. Here water, three to four feet deep, issued from the ground, where before and after no openings were discernible. What seems to be conclusive proof that the underground drainage is from Bellevue to Castalia, is supported by the results of investigations made by Dr. F. M. Houghtaling, Erie County Health Commissioner. He writes,[3] "Several years ago I was quite concerned about the water supply of the Blue Hole at Castalia and made repeated bacterial examinations and found nearly all deep water wells between Bellevue and Castalia and the flowing wells in the region of Vickery contained B-coli in sufficient numbers to make the water unsafe for domestic use. The waters of the Blue Hole will develop gas-forming bacilli within twenty-four hours with a high bacteria count when plated. As no doubt you are aware, there is no sewage disposal at Bellevue. It has been the custom for years to drill wells until the drill drops into a cavern, and then pull the tools and test it by putting a fire hose in for several hours. It was evident to me that this was the source of contamination. To prove my judgment I placed one pound of Uraline dye in a flush bowl in Bellevue. This colored the water definitely for a distance of three miles on the Bellevue-Castalia road. I had a faint reaction five miles from Bellevue and three miles from Castalia. I am satisfied that if I had used two or three pounds of dye I would have made the Blue Hole a bright green color. The expense stopped me from further experiment. When you consider the amount of water that this dye will color, and the distance in which the dilution

[3]Personal communication, 1932.

was so great that it faded out, proved to me that there is a large body of water under this area."

The Castalia springs are four in number and discharge into a pond a few acres in extent, located in the central and east portions of the village. About twenty-five thousand gallons of water are supplied to the pond per minute. This volume formerly flowed across the prairie on the north and through the marsh southeast of Bay Bridge by means of a stream, now extinct. This creek flowed northeast four miles from the shore of Sandusky Bay, at a point one and one-fifth miles east of Bay Bridge and joined the old Sandusky River a quarter of a mile upstream from Mill's Creek near Johnson's Island. With the advent of man, the prairie to the north and west of Castalia was too wet for trees. This area has been artificially drained by canals, leading the water north and northeastward into two branches of a creek flowing into the bay at Venice. The entire stream course has been known as Cold Creek.

The great marl beds used for cement by the Sandusky Portland Cement Company at Bay Bridge were formed in the flooded area north of Castalia, from the spring waters which contain a high percentage of calcium carbonate. The abundance of tufa at the surface makes it impossible to plow the land, which can be used for pasturage only. The marl bed area has always presented dismal agricultural prospects and it required little persuasion for the owners to sell their land to a "sporting club organization." Chemical analysis revealed the great value of the tufa deposits which are in demand for cement and other products. The tufa was formed by a plant known as the chara which grows in water containing carbonate of lime. This it takes from the water in which it lives; after it dies the resulting travertine becomes encrusted with the same substance, forming tufa. Travertine or tufa is composed of about 97% of calcium carbonate, 1% of magnesium carbonate, and lesser quantities of barium sulphate, aluminum, iron and silica. Willow Point, located half-way between Bay Bridge and the mouth of the Sandusky River is a gravel beach half a mile long, several yards wide and rising not more than three feet above the usual bay or lake level. The marsh back of the beach contains no tufa and therefore the pebbles must have been derived from the marl beds underlying and below the level of the bay. Marl is excavated by the Sandusky Portland Cement Company in

many places at a depth of five or more feet below the level of the bay. This is evidence that the lower reaches of the Sandusky River have been drowned producing an estuary, Sandusky Bay.

The Blue Hole is not more than one hundred and ten years old; it came into being about 1820 when the pressure caused by the rising of the water of the upper pond in Castalia, as the result of a dam, weakened the strata above the Blue Hole and occasioned its collapse into the cavernous depth. This dam was located in front of the church in the center of the village where the pond emptied into the outlet stream. The new spring has since had a sympathetic relationship with the larger and less beautiful pond to the south. Undermining has proceeded since the original collapse, for early in 1914 another cave-in occurred leaving the Blue Hole with its present dimensions, roughly circular, averaging seventy-five feet in diameter. The Blue Hole did not gain wide publicity until about 1879, because it was inaccessible except by boat. The organization of the Cold Creek Trout Club, brought about the banking of the marshy edges of the Blue Hole so that one could walk about the orifice. Today the area to the south and less to the east and west is still very moist and few trees of any size can grow there.

Contrary to prevalent belief, the depth of the Blue Hole is not unknown, but has been sounded and found to be about forty-three to forty-five feet deep. The deepest point is near the south margin, where on a sunny day one may follow the descent of a small object through the limpid water to the mysterious depths below. The sun must be shining in order to penetrate the depths, for the surface otherwise acts as a mirror. Therefore the summer time is the best season in which to fully appreciate the vast, quiet beauty of the Blue Hole. The surface remains undisturbed, even though there is a constant volume of water coming from below. About five thousand gallons of water per minute escapes from the Blue Hole, through two outlets, over artificial cascades made to aerate the water which is lacking in free oxygen. Trout cannot live in the Blue Hole because of the lack of free oxygen. The volume of water and its temperature remain remarkably constant throughout the year. Drought and rainfall show a slight influence; the flow is regulated beneath the surface in a manner comparable to the regulatory influence that a mantle

of trees and grass has over the surface drainage. During and after the drought of 1930 the Blue Hole showed no noticeable volume change. The temperature of the water does not vary appreciably during summer and winter; the maximum fluctuation is about 5° Fahr., that is from 46° to 51°. This fact, and the huge volume of water supplied by all the springs, prevents Cold Creek from freezing during the winter. Consequently, mills were established at an early date along the

Fig. 2. The Blue Hole of Castalia.

five-mile length of Cold Creek to Sandusky Bay. The constant source of power throughout the year was of great value to the early pioneer.

The Blue Hole and other springs at Castalia send out thirty thousand gallons of water per minute into the canals which extend north a mile and a half to the club house of the Castalia Sporting Club, where they join in a single straight channel, the length of which extends an equal distance to the northeast. To this point the fall averages seven feet per mile and now descends by two cascades into a natural stream

course ten feet below. Here is the site of a stone mill which was originally built in 1839 and destroyed by fire in 1888. The ruins are now seventy feet from the cascades; in forty-five years the falls have retreated this distance. Castalia (640-650 feet) is approximately seventy feet above mean lake level (573 feet) and Cold Creek has a fall of fifty-seven feet to Gallagher's Mill at Venice where the only mill along the creek is located.

The Castalia springs at an early date attracted attention because of their cold water and constant flow throughout the year. Ideal conditions existed for the establishment of grist mills and many were built and operated during the past century. The village of Venice was founded at the mouth of Cold Creek in 1816 and became of increasing importance as a milling center. During the coldest winter ever recorded, Cold Creek was the only creek not to freeze over. All southern Michigan and northern Ohio were dependent on the Venice mill for the grinding of flour. During the dry summers when there was an insufficient supply of water to operate the mills the farmers brought their grain for great distances to the mill at Venice. Carp ponds now flourish at Venice; the cold water allows the fish to be kept healthy until ready for the eastern market. Distilleries, tanneries, paper mills and cotton mills have during the past one hundred and twenty years been established on Cold Creek and at Castalia because of the purity of the water, its low temperature and power. In 1868, Cold Creek was first stocked with speckled trout. It was not long until the Castalia Sporting Club was organized (1878). The next year the Cold Creek Trout Club originated. In 1887 the former reorganized as the Cold Creek Sporting Club and later again changed its name; this time to the present Castalia Trout Club whose club house is located just beyond the Blue Hole. Farther down stream is the "Lower Club" (Castalia Sporting Club). On the grounds of the younger club are twelve miles of trout stream supplied by a private hatchery located just east of the Blue Hole. German Brown Trout were once artificially propagated until it was discovered that they fed on the smaller trout. Nevertheless, this species still persists and on occasions some as large as eight pounds are caught. Rainbow and Steelhead trout are the other two species now stocked in the stream. Four to eight thousand fry are hatched every year and much care is taken to see that

the proper amount of food organisms are supplied to the growing fish. The Steelhead or Salmon trout were experimented with eight years ago by the Castalia Trout Club, but the fear that they would exterminate the other trout is the reason why the fry were freed in Sandusky Bay.[4] Lately fishermen have been catching seven, six and five year old Steelhead trout in Sandusky Bay, ranging up to twelve pounds in weight. This proves that this species of trout can spawn in these waters, probably opposite the mouths of the spring-fed streams that empty into the bay. Sandusky Bay is located, throughout its fifteen mile length, above the Monroe limestone from which cold springs well out under the bay and lower the temperature below that of Lake Erie, making it possible for Steelhead trout to multiply and provide sportsmen with a fighting game fish that is obtainable only in the Rogue River in Oregon. The full grown trout weigh twenty or more pounds. The State recently purchased a twelve acre area near Vickery; a huge volume of cold water from the springs there is ideal for fish propagation.

[4]Sadler, Webb, Member of Castalia Trout Club.

The Invertebrata.

For many years there has been a real need for a satisfactory one-volume text and reference work on invertebrate zoology—one that would embody the present-day knowledge of taxonomy, morphology, and phylogeny, and also emphasize the physiological and ecological aspects of the subject. The first volume of Parker and Haswell's Textbook of Zoology, which thirty-five years ago admirably filled this need, has undergone but little change in its successive editions; and no other work of comparable scope and size has appeared. The present volume, the work of English zoologists and English printers, comes closer to meeting the demand than any other book published in recent years.

The book is well organized, and shows evidence of much careful, painstaking work. The classification adopted combines conservatism with the utilization of the general results of recent taxonomic work. The chief emphasis throughout is morphological. However, the treatment of the theoretical side of invertebrate morphology, which can be used to such good advantage to give coherence and add interest to this subject, is extremely limited. The discussion of evolution and phylogeny also seems inadequate, and sometimes lacking in understanding. Thus the statement, (p. 2), that ". . . . the Platyhelminthes or flatworms seem to be related to the annelid stock. Their lack of coelom is a difficulty in this respect."

The typography, in general, is good. The type used for the text is slightly smaller and more closely spaced than is usual in zoological textbooks, and many of the drawings are on a smaller scale than might be desired, and these things detract somewhat from the attractiveness of the printed pages. Most of the illustrations are simple, clear line drawings; many of them have not previously been seen in textbooks.—W. J. Kostir.

The Invertebrata: A Manual for the Use of Students, by L. A. Borradaile and F. A. Potts, with chapters by L. E. S. Eastham and J. T. Saunders. xiv+645 pp. 458 figs. New York, The Macmillan Company (Cambridge, England: At the University Press), 1932. $5.50.

STUDIES IN HUMAN INHERITANCE. IX.

The Inheritance of Taste Deficiency in Man.

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The establishment of linkage in man has long been one of the objectives in the writer's laboratory. To this end any unit character in man which occurs with reasonable frequency in the general population must be carefully analyzed and its unit-character nature established or disproven beyond question.

Among the most recently discovered of the unit characters in man is the so-called "taste blindness" or taste deficiency. The hereditary nature of this trait was established in 1931 by Snyder with 100 families, and by Blakeslee and Salmon with 47 families, following Fox's original discovery that taste deficiency actually existed. The final proof of the unit-character nature of any human hereditary factor, however, must lie in the mathematical analysis of the data, since we are unable to distinguish accurately between heterozygous and homozygous dominants in man. We are therefore unable in this particular instance to predict directly the ratios of tasters and non-tasters among the offspring of various matings.

Such predictions can be made, however, on a frequency basis. Since in our linkage studies it is essential for us to be certain of the unit-character nature of the taste deficiency, there is presented here the statistical analysis of the inheritance of taste deficiency among 800 families which have been studied at the Genetics Laboratories of the Ohio State University.

To Dr. Fox, of the DuPont Laboratories, we owe the accidental discovery that a small crystal of para-ethoxy-phenyl-thio-carbamide placed on the back of the tongue may produce one of two characteristic reactions. To some persons it will give an extremely bitter sensation, somewhat like quinine. To others no bitter taste at all will be apparent. The reaction is clear and distinct, and practically no doubtful cases are encountered. Since phenyl-thio-carbamide reacts the same as para-ethoxy-phenyl-thio-carbamide, we have used the former substance as being more readily available to us.

The results of our study of 800 families are given in Table I. It will be noted that the taste deficiency appears to be a simple

recessive character. Where neither parent tastes the compound, practically none of the children do. The small fraction of a percent exceptions may be due to illegitimacies, adoptions, errors in technic resulting from the fact that the phenomenon is a subjective one entirely, or to the possible taste-suppressing effect of some environmental agent of which we know nothing at present. We do know that acidity or alkalinity of the mouth, age, sex, and other tested variables apparently have no effect upon this taste deficiency.

TABLE I.

SUMMARY OF 800 FAMILIES STUDIED FOR INHERITANCE OF TASTE DEFICIENCY FOR PHENYL-THIO-CARBAMIDE, SHOWING OBSERVED AND CALCULATED PROPORTIONS OF TASTERS AND NON-TASTERS IN THE OFFSPRING OF THE VARIOUS TYPES OF MATINGS. TOTAL FOR 3,643 PARENTS AND CHILDREN: TASTERS, 70.2%; NON-TASTERS, 29.8%.

MATINGS	CHILDREN	
	TASTERS	NON-TASTERS
Taste × Taste 425	929 obs. 0.877 ± .007 calc. 0.876 ± .001 dev. 0.001 ± .007	130 0.123 ± .007 0.124 ± .001 0.001 ± .007
Taste × Taste deficient 289	483 obs. 0.634 ± .012 calc. 0.646 ± .002 dev. 0.012 ± .012	278 0.366 ± .012 0.354 ± .002 0.012 ± .012
Taste deficient × Taste deficient 86	5 obs. 0.021 calc. 0.000 dev. 0.021	218 0.979 1.000 0.021

Where both parents taste, the ratio of tasters to non-tasters in the offspring is about 7:1. This of course varies from the familiar 3:1 because a certain proportion of the tasting parents will be homozygous, producing all tasting children. The expected ratio of tasters and non-tasters among the offspring can only be calculated by first determining the frequencies of the allelomorphic factors in the general population. The same applies to families in which only one parent tastes, in which the familiar back-cross ratio of 1:1 will be changed due to the fact that some of the tasters will be homozygous.

The determination of the frequencies of the genes, the expected proportions of tasting and non-tasting children in various matings, and the consequent proof of the unit-character nature of the deficiency are given below.

Let us assume the taste deficiency to be a simple recessive character, designating the two allelomorphs as T and t, respectively.

Let p = frequency of T
and q = frequency of t.
Then $p + q = 1$. It is readily seen that

$p^2 + 2pq$ = tasters (A)
q^2 = non-tasters (B)
$q = \sqrt{B}$
$p = 1 - \sqrt{B}$

In this case $p = .445$, $q = .545$
Since p^2 = homozygous tasters
and $2pq$ = heterozygous tasters,

$\frac{p^2}{p^2 + 2pq}$ = proportion of tasters which are homozygous

$\frac{2pq}{p^2 + 2pq}$ = proportion of tasters which are heterozygous.

From this it is easy to calculate the relative frequencies of matings of homozygous with homozygous, homozygous with heterozygous, and heterozygous with heterozygous, and consequently the proportion of recessive, non-tasting children to be expected from such matings. Since the only recessive children so produced will be one quarter of the offspring of heterozygous with heterozygous, a formula for this is readily derived. Similarly the calculation can be made for matings of tasters with non-tasters, where the recessive children will be one half of the offspring of matings of heterozygous with recessive. These formulae may be derived as follows:

Let R = proportion of recessive offspring to be expected from matings of dominant with dominant, and

S = proportion of recessive offspring to be expected from matings of dominant with recessive.

$$\text{Then } R = 1/4 \left(\frac{2pq}{p^2 + 2pq}\right)^2 = \left(\frac{q}{p + 2q}\right)^2$$

$$\text{and } S = 1/2 \left(\frac{2pq}{p^2 + 2pq}\right) = \frac{q}{p + 2q}$$

Since the frequencies p and q will vary for different samplings, the figures obtained from these formulae will of course vary, not only for other mutations occurring with different frequencies, but even for the same mutation in different races or populations. The frequencies of the allelomorphs must therefore be determined anew for each mutation of each new race.

By referring to Table I it can be seen that the deviations of the observed proportions from the expected proportions are well within their probable errors. The unit-character nature of the taste deficiency is thus amply proven.

The inheritance of taste deficiencies for still other compounds has been investigated in our laboratory and the results of these studies will soon be in press.

The probable errors of the observed and calculated proportions as given in Table I were obtained as follows:

$$\text{For the observed values, P. E.} = .6745\sqrt{\frac{ab}{N}}$$

Where a = observed proportion of tasting children, b = observed proportion of non-tasting children, and N = number of offspring, for each type of mating.

For the calculated values, the probable error must be specifically derived. The complete derivation of these formulae is being given in a paper on the epistatic relationships of two types of taste deficiency, which we are now preparing for publication in "Genetics." For the present merely the resultant formulae are given. These are as follows:

$$\text{P. E.}\left(\frac{q}{p+2q}\right)^2 = \frac{.6745\ (1-\sqrt{b})}{4\,N\,(1+\sqrt{b})^2}\sqrt{\frac{16\,Nb}{1-b} - 1 - \frac{(1-2\sqrt{b})^2}{(1+\sqrt{b})^2} + \frac{2\,(1-2\sqrt{b})}{1+\sqrt{b}}}$$

$$\text{P. E.}\ \frac{q}{p+2q} = \frac{.6745}{8N\,(1+\sqrt{b})}\sqrt{\frac{16N\,(1-\sqrt{b})}{1+\sqrt{b}} - \frac{(1-\sqrt{b})^2}{b} + \frac{4\,(1-\sqrt{b})^2}{(1+\sqrt{b})\,\sqrt{b}} - \frac{4\,(1-\sqrt{b})^2}{(1+\sqrt{b})^2}}$$

Where b = the true value of the proportion of non-tasters in the population, which in practise must be taken as B, the observed value from the complete sample of individuals tested. N = total number of individuals tested.

A word may be added as to the inheritance of taste deficiency to di-ortho-tolyl-thio-carbamide, another compound investi-

gated. Approximately 35% of the individuals tested could taste both compounds, an equal number tasted only phenyl-thio-carbamide, and about 30% could not taste either compound. Moreover, in many families where neither parent tasted the second compound, some of the offspring did. This indicates an epistatic relationship of the two factors concerned. The analysis of this phenomenon, as well as the derivation of all formulae concerned, will be given in the previously mentioned forthcoming publication.

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An Introduction to Physical Science.

The title of this book, "Introduction to Physical Science," suggests that it might give a unified approach to the study of both physics and chemistry. Such, however, is not the case unless one concedes that physics is to be regarded as prerequisite to the study of chemistry and in that sense becomes an introduction to the study of chemistry. The intent of the book, however, is to introduce the student to the methods of scientific thinking as found in classical and modern physics and to acquaint him with some of the results of modern research in physics. The author recognizes in the preface the difficulty of compressing into such a limited space the necessary fundamental training for an appreciation of the developments which have characterized the last quarter of a century of physics and he is in my opinion correct in supposing that an introductory course in physics must include a survey of these newer developments as well as a consideration of the principles of classical physics.

In the selection and arrangement of the subject matter the author has been quite independent of the traditional order of presentation as found in most text-books of physics and has undertaken to present the essential principles of mechanics, heat, sound, light and classical electricity in sufficient detail to make it possible to understand selected topics from modern physics. Such topics as cathode rays, x-rays and positive rays, radioactivity, electric oscillations, relativity and wave mechanics are considered in somewhat greater detail than in most college text-books of physics. There is also an interesting chapter on cosmic physics. The chapter on wave mechanics and also the chapter on relativity seem to me to be too difficult for the type of student for whom the book was intended. The book seems clearly written, but many students and instructors will miss those more concrete illustrations and applications of physical principles which tend to make physical reasoning intimate and vital.

This book should serve as an excellent introduction to more advanced work in physics.—Alpheus W. Smith.

Introduction to Physical Science, by Carl W. Miller. New York, John Wiley and Sons, Inc., 1932. $3.00.

BRYOZOA FROM CHESAPEAKE BAY.*

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The Bryozoa of Chesapeake Bay are interesting for several reasons: first, because of the unusual nature of the bryozoan fauna; second, the region is zoogeographically intermediate between the colder water fauna of New England and the subtropical fauna of Florida, and, third, there is almost no mention of this group between Southern New England and Florida in the literature.

The number of species taken by the Survey, nineteen, is much smaller than would have been expected from the area covered, and there is little doubt that a much larger number could be taken by careful collecting about the mouth of the bay. The purpose of the Survey was not to produce an extended list but to report the presence of the species occurring in certain areas. A large amount of material from more than 40 stations within the bay was carefully worked over. The stations extended from the mouth of the bay nearly to the city of Baltimore, but at the uppermost stations no Bryozoa were taken and most of the species were limited in distribution to the lower third of the region surveyed. Certain species of Ctenostomata were the only ones that could be considered abundant. One species of this group (*Victorella pavida*) is recorded for the first time in American waters, and another (*Amathia alternata*) has not been reported since Lamouroux reported it in 1824.

The bottom of the bay appears to consist almost entirely of mud, mixed in places with sand and shells. Apparently enormous masses of hydroid stems are drifted over the bottom. The writer assumed the task of separating the Bryozoa from the Hydrozoa and was continually astonished at the amount of dead hydroid material. It appears that most of this material must have been brought in by tides and currents from somewhere near the mouth of the bay, for these hydroids also do not flourish where the salt content is too low. Over a

*A report on the species of the off-shore waters collected by the Biological Survey of Chesapeake Bay, under the direction of Dr. R. P. Cowles. Published by permission of the United States Commission of Fisheries.

large part of the bay where Bryozoa may grow, these stems seem to be the only means of attachment for the various species recorded.

The water is made more or less brackish by the inflow from an unusual number of larger rivers; the Susquehanna, Patapsco, Patuxent, Potomac, Rappahannock, York and James, besides numerous smaller streams. No doubt this has an important bearing on the distribution of the Bryozoa, few of which are able to live in water that is less than two thirds of the salinity of pure sea water. According to records for 1920, 1921 and 1922, the salinity varies from about .7% near Baltimore to about 3.2% at the mouth of the bay. Only the bottom records are considered as the Bryozoa are all attached species. The salinity of the open ocean averages about 3.5 % of salts, and about 2.0% seems to be the lower limit of salinity for most of the bryozoan species.

The whole region within the bay is very shallow, 45.75 meters being the greatest depth, near the mouth of the bay, while most of the stations show less than one-third of this depth. Such a body of water influenced by a large inflow from the rivers, necessarily fluctuates greatly in temperature, even at the bottom, and this also no doubt affects the distribution of the species.

ENDOPROCTA

Barentsia discreta (Busk).

Sta. 8903, not far from the mouth of the bay, at 47.75 meters. One small colony attached to a stalk of *Amathia alternata*. A widely distributed species, but recorded rather infrequently. On the North American coast the writer has taken it at Woods Hole, Massachusetts; Beaufort, North Carolina, and the Tortugas Islands, Florida.

ECTOPROCTA

Cyclostomata

Crisia eburnea (Linnaeus).

Sta. 8850, 8938 and 8940, all in the lower third of the bay. The species is cosmopolitan in distribution.

Cheilostomata

Bugula turrita (Desor). (Plate I, Fig. 1.)

Sta. 8827, mouth of bay, 18.3 meters, two small colonies attached to shell fragments. This abundant species of the southern New England region appears to be much less common south of New Jersey, though the writer has taken it as far south as Beaufort, North Carolina.

Bugula gracilis var. *uncinata* Hincks.

Sta. 8893, not far from the mouth of the bay, at 44.83 meters. The species is known from Woods Hole and Lynn, Massachusetts, from England and Madeira. Where found it does not seem to be a common species, but probably its optimum habitat has not been located.

Nitscheina (*Membranipora*) *membranacea* (Linnaeus).*

Sta. 8949, at 7.78 meters, about half way up the bay, one colony on algae. It was also taken at another station the number of which was obliterated, but the date indicates that the location is somewhere off the city of Annapolis. This is the farthest up the bay that any bryozoan species was taken. *N. membranacea* is well known for its tolerance of brackish water conditions in various regions of the world.

Electra (*Membranipora*) *pilosa* (Linnaeus).

Sta. 8838, mouth of bay, 16.4 meters, one colony on a shell fragment. A very widely distributed species.

Electra (*Membranipora*) *monostachys* (Busk).

Sta. 8838, at mouth of bay, 16.4 meters, on shell fragments. Widely distributed in the North Atlantic.

Hemiseptella (*Membranipora*) *denticulata* (Busk).

Occurring at nine stations well distributed over the lower part of the bay and north to the mouth of the Potomac River. The lowest salinity where it occurred was about 1.5%. One colony was bilaminate and spread from branch to branch of a hydroid. A common species from Cape Cod southward to Florida and found also on the west coast of Mexico.

Hippothoa hyalina (Linnaeus).

Sta. 8827, mouth of bay, 18.3 meters. A very widely distributed species.

Schizopodrella unicornis (Johnston).

Sta. 8173, near mouth of bay, 12.8 meters. Also a common species occurring over a very wide range.

Microporella ciliata (Pallas).

Sta. 8173, mouth of bay, 18.3 meters. Cosmopolitan in range.

Ctenostomata

Alcyonidium polyoum (Hassall), (*A. mytili* Dalyell).

Sta. 8827, near mouth of bay, one colony on a shell. Widely distributed.

Alcyonidium verrilli Osburn. (Plate I, Figs. 2 and 3.)

Taken at 22 stations ranging all over the lower part of the bay

*For references and synonymy see Osburn, Bryozoa of the Woods Hole Region, Bul. U. S. Bureau of Fisheries, Vol. XXX, No. 760, 1912. The generic names in parenthesis are those used in that report.

up to above the mouth of the Potomac River, at depths ranging from 7.3 to 45.75 meters. The lowest salinity observed was at the mouth of the Potomac River, 1.319‰. This species was the most abundant and widely distributed of all the Bryozoa taken by the Survey. Numerous young colonies incrusted hydroid stems, and larger colonies, branching freely, rose to height of 100 to 125 mm., with branches 3 to 5 mm. in diameter. The colony appears to begin as a thin layer, which later rises into the erect branching form. In consistency this species is much firmer than *A. gelatinosum* and *A. hirsutum*, both of which grow in somewhat the same branching form.

Hitherto the species has been recorded only from southern New England and New Jersey.

Alcyonidium parasiticum (Fleming).

Sta. 8838, mouth of bay, 16.4 meters, encrusting hydroid stems.

Anguinella palmata Van Beneden.

Taken at eight stations, all well within the bay in the general region of the mouth of the Potomac River, the salinity ranging from about 1.3 to 2.1‰. This distribution appears to be characteristic since at Beaufort, North Carolina, where the species is abundant, it thrives especially on the piles of docks well within the harbor, and at Buzzard's Bay, which appears to be its northern limit, it occurs in a similar situation.

Bowerbankia gracilis Leidy.

Noted at five stations ranging from near the mouth of the bay to about three-fifths of the way toward the head, the salinity varying from 1.5 to 2.4‰. All of the colonies were spreading over hydroid stems, sometimes covering them as with a dense fur. Most of the specimens were of the variety *caudata* of Hincks.

Amathia alternata Lamouroux. (Plate I, Fig. 4.)

1816, Hist. Pol. Cor. Flex., p. 160.
1821. Exp. Method, p. 10, Pl. LXV, Figs. 18–19.
1824, Encycl. Method, p. 44.

Recorded from seven stations all in the lower fifth of the bay, at depths ranging from 12.8 to 45.75 meters. The species is not so abundant, nor does it reach so large a size as it does farther south, though the largest colonies attained a height of 75 mm. It has not been recorded for the coastal waters of North America, although the writer has found it to be very abundant at Beaufort, North Carolina, where it is thrown up on the outer beaches in great numbers. The erect, tree-like, light brownish colonies, with their spirally arranged zooecia and tough stems, are like nothing else in our fauna. The larger stems measure about .5 mm. in diameter, the retracted zooecia average about .6 mm. in length by about .135 mm. in width and in each group they are graduated somewhat in length from the lower zooecia upward. The spirals may alternate in direction, turning either to right or left in the same colony.

It appears unusual that so large and striking a species should not have been recorded by anyone for more than a century and remain known only from the type material, but the species of Amathia are not very well known and it is possible that it has been recorded under another name. Lamouroux, in his first description named Deshayes as the collector and the locality as "mer d'Amerique," but in his revised statement in 1824 he gives the locality as "mer des Antilles," with the same collector. The probability therefore is that Deshayes found the species somewhere about the West Indies.

I am indebted to Dr. Sidney F. Harmer, the eminent English authority on the Bryozoa, for his opinion, confirming my own, that this species is the *alternata* of Lamouroux.

Victorella pavida Saville Kent. (Plate I, Fig. 5.)

Kent, Quart. Jour. Micr. Sci., n. s., Vol. X, p. 34, Pl. IV.
Hincks, British Marine Polyzoa, p. 561, Pl. LXXIX, Figs. 4–7.
Kraepelin, Abhand. Verein Hamburg, Vol. X, Taf. III, Fig. 75.

Taken at four stations, 8874, 8883, 8891, and 8893. The distribution ranges from near the mouth of the bay to well above the mouth of the Potomac River, with the salinity varying from 1.7 to 2.7‰. This species was a surprise in the collection as it had not been previously recorded from American waters, though it is known from England, Germany and Australia. It is supposed to occur only in waters of slight salinity, "amongst a prevailing fluviatile fauna," (Hincks).

The zooecia look like those of a very delicate *Bowerbankia* in general appearance, though the type of budding is quite different (Fig. 5), there is no gizzard and there are only 8 tentacles. Knowing the variability in appearance of many ctenostomes in different states of preservation, I was somewhat doubtful of my determination of the species as *V. pavida*, and submitted specimens to Messrs. S. F. Harmer and R. Kirkpatrick of the British Museum for comparison. Kirkpatrick writes as follows: "Your example differs a good deal from the typical material, but on the other hand resembles closely the figures of Kraepelin. We are both inclined to think you would not be far wrong if you named your specimen *Victorella pavida*." So the determination stands at present and must remain until better preserved material can be properly studied.

Triticella (*Hippuraria*) *elongata* (Osburn).

In the gill chamber and spreading slightly on the outside of the shell of a blue crab (*Callinectes sapidus*) from Fish Hawk Sta. 8498,

Chesapeake Bay. No crabs were sent me by the Survey, but one of two specimens received from the U. S. National Museum bore this species, which seems always to be associated with crabs, especially spreading over the walls of the gill chamber. *T. elongata* is probably common enough on various species of the Chesapeake crabs, as the writer has taken it at Woods Hole, Massachusetts, and more abundantly at Beaufort, North Carolina, on the blue crab, the spider crabs (*Libinia* spp.) and on the species of *Pinnixia* which inhabit the tubes of the worm, *Chaetopterus*.

It is worthy of note that in the preceding list nearly all of the species have a very wide distribution. Only four, *Bugula turrita*, *Alcyonidium verrilli*, *Amathia alternata* and *Triticella elongata*, are limited, as far as our present knowledge goes, to the Atlantic Coast of North America.

EXPLANATION OF PLATE.

Fig. 1. *Bugula turrita* (Desor), a well developed specimen from Long Island Sound. Natural size.

Figs. 2 and 3. *Alcyonidium verrilli* Osburn, showing differences in form of colony. About one-half natural size.

Fig. 4. *Amathia alternata* Lamouroux, a typical colony but spread out somewhat for photographing. The opposite direction of the spirals may be observed on some branches. Natural size.

Fig. 5. *Victorella pavida* Kent, diagrammatic drawings showing mode of branching and other details.

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THE NEWARK DRAINAGE SYSTEM IN KNOX, LICKING, AND NORTHERN FAIRFIELD COUNTIES.

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INTRODUCTION.

The Newark Valley was first named and described in a paper written by G. W. Tight and published about 1897 in Vol. VIII of the Bulletin of Denison University. The general features of this valley were noted and the probable outlet to the southwest was discussed by Leverett in 1902.[1] Since that time papers by various authors have appeared from time to time in the Bulletin of Denison University dealing with local changes of drainage in the vicinity of Granville, Newark, and Hanover, but little concerted effort has been made to add to the data on the Newark Valley or to map out and record the drainage of Newark age in the region lying north of Newark in Licking and Knox counties.

In his report on Knox and Licking counties, Read mentions some old filled channels in the vicinity of Mt. Vernon and Martinsburg.[2] In his early work Tight states that "the preglacial channel of North Fork probably extended into Knox County and received the head waters of Owl Creek,"[3] but later as reported and approved by Leverett he considered that a divide crossed the North Fork near Utica and that the waters north of this divide discharged into the Scioto basin through an old channel extending westward past Homer.[4] In a later paper Scheffel concludes that the drainage of the lower portions of the valleys of Raccoon Creek, Brushy Fork, and North Fork drained into the Newark Valley.[5] Much data is now available in the form of well records which did not exist at the time of the early investigations but which adds

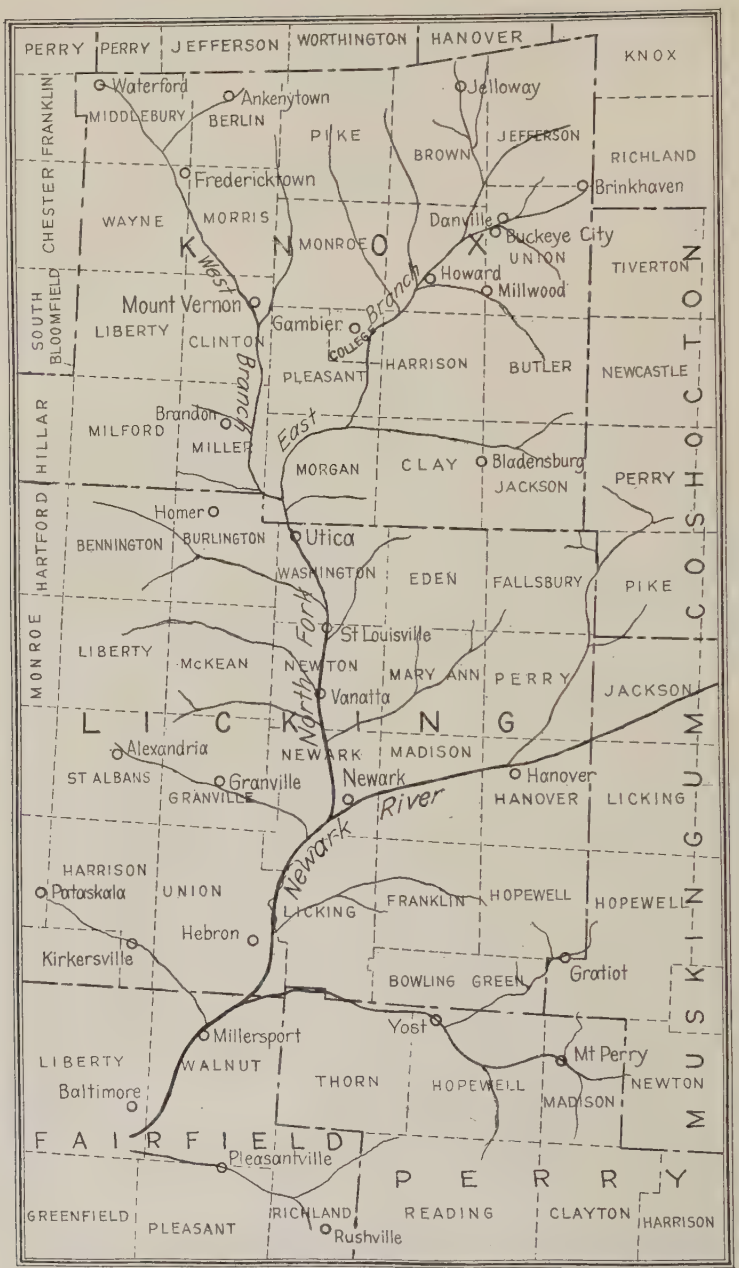
[1]Leverett, Frank, U. S. Geol. Survey, Mon. XLI (1902), p. 155.

[2]Read, M. C., Geol. Survey Ohio, Vol. III (1878), pp. 325–361.

[3]Tight, W. G., A Contribution to the Knowledge of the Preglacial Drainage of Ohio. Bull. Denison University, Vol. VIII (1897), p. 37.

[4]Leverett, Frank, U. S. Geological Survey, Mon. XLI (1902), pp. 160–161.

[5]Scheffel, E. R., Drainage Changes Near Granville, Ohio. Bull. Denison University, Vol. XIV (1908), pp. 171–172.



Map showing the location of the old Newark River and the drainage tributary to it in Knox, Licking, and northern Fairfield counties.

much to our detailed knowledge not only of the Newark Valley but of the Newark drainage system throughout eastern Licking and Knox counties. To record such data and to state the conclusions derived from its study is the purpose of this paper.

During the past thirty years many deep wells have been drilled to the Clinton sand over a broad belt extending from Lancaster, Fairfield County, northward past Newark and Granville to Mt. Vernon and also along the old valley from Newark east to Frazeysburg. The records of several hundred wells located in these areas have been secured, their locations carefully plotted on maps, and the lengths of the drive pipe noted. Where such locations occur along streams or on flat lands the well-head and bed rock elevations have been determined within narrow limits of error. Where rock gorges occur partially or completely filled with glacial drift, it is necessary in figuring valley profiles to assume that the lowest bed rock elevation in any locality represents the old valley bottom. The chief drainage lines of the old Newark system in Licking and Knox counties which have been determined in this way are shown on the accompanying map.

THE NEWARK VALLEY.

The Newark Valley extends from Trinway past Frazeysburg and Hanover to Newark where its course turns more to the southwest. East of Newark the valley is a distinct topographic feature but southwest of that town it is so choked with glacial drift that beyond Buckeye Lake its position can not be determined by surface contour. Its course, however, can be traced by well records as far as Baltimore, Liberty Township, Fairfield County. Beyond Baltimore very few wells have been drilled and therefore little data can be secured. However, the most likely course for the old channel is westward past Canal Winchester where in all probability it turns to the southwest meeting the axis of the Scioto basin a short distance north of Circleville.

Between Newark and Frazeysburg the old valley is rock bound for outcrops are present along its slopes high above present bottom flats. The filling varies in thickness from 314 feet at Newark to about 165 feet near Trinway. Many wells drilled near Black Run in the northwestern part of Jackson Township, Muskingum County, record alluvium in this valley of 200 feet or more in thickness. At the C. B. Fawcett well

located near the center of the valley about 2 miles west of Trinway, bed rock was struck at a depth of 166 feet, giving an elevation for the rock floor at this place of about 600 feet above tide. At the Amos Zartman well just south of the fairgrounds at Newark and also situated near the center of this old valley, bed rock with an elevation of 537 feet was reached at a depth of 297 feet below the surface. The distance between these two wells is about 22 miles making an average slope of the valley floor to the southwest of about 34 inches per mile.

From the west edge of Newark the old channel is directed a little west of south passing a short distance east of Hebron to the north shore of Buckeye Lake. Here the valley turns to the west and extends beneath the western end of the lake as far as Millersport where it again turns to the south and passes about a mile northwest of Thurston to a point approximately one mile south of Baltimore. The maximum thickness of the drift in this part of the valley is about 350 feet. In the region lying immediately north of Buckeye Lake wells penetrate drift ranging from 65 to 345 feet in depth. The lowest point of which we have record in the old channel in this vicinity was reached in the Cliff Sturgeon No. 3 well located on the north shore of the lake about one mile southwest of the electric railway terminal. The drift here has a thickness of 344 feet and the elevation of bed rock is about 540 feet.

Southwest of the west end of Buckeye Lake glacial drift in excess of 300 feet in thickness is of common occurrence. At the Marie Fry No. 1 well in the south part of Section 27, Walnut Township, the drift measures 316 feet, while the elevation of bed rock is about 585 feet. The record of the Thomas Bryson No. 1 well in Section 4, Walnut Township, shows 388 feet of drift with bed rock at a height of 550 feet. Deep wells drilled at Thurston and Baltimore penetrate drift exceeding 300 feet in thickness,and reach bed rock at elevations of approximately 550 feet. Records now available indicate that the lowest elevation of bed rock in the old valley occurs in the northwestern part of Section 30, Liberty Township, where in the Adam Wagner No. 1 well the drift has a thickness of 339 feet and the rock floor has a height of about 521 feet above sea level which is about 17 feet lower than at the Zartman well at Newark. The distance between these two wells measured along the channel defined by well records is

about 17.7 miles. The average fall to the southwest is therefore about 10.8 inches per mile for that part of the valley between Newark and Baltimore. If this gradient were projected along the most probable course past Canal Winchester in the direction of Ashville, the elevation of the channel at the latter place would be about 500 feet. That thick deposits of drift occur near Ashville is evidenced by the record of the L. C. O'Daffer well drilled about one mile northwest of town where bed rock having an elevation of 535 feet was reached at a depth of about 167 feet.

VALLEYS TRIBUTARY TO THE NEWARK CHANNEL.

Southwest of Newark the upper surface of bed rock rises rather abruptly along the east side of the old Newark channel for it reaches heights of 150 to 200 feet in the horizontal distance of a mile. The regularity of the slope is broken at a few places by tributary channels which received waters from the region lying to the eastward. One of the largest of these tributaries had its head waters in the northwestern corner of Reading Township, Perry County. It extended to the southwest across northern Richland Township to a point a little south of Shakes Run School where it turned to the northwest, passed through Pleasantville, and united with the Newark Valley south of Baltimore. It was joined from the south by a tributary valley which headed a short distance southwest of Rushville, flowed northwest, and met the main tributary in the northwestern corner of Section 20, Richland Township. The position of these tributary valleys is marked by an excessive thickness of drift. In the central part of Section 10, Richland Township, the drift has a thickness of 195 feet. Wells drilled near Shakes Run School show 240 and 273 feet of drift while at Pleasantville the drift reaches a thickness of 322 feet.

A second and larger tributary entered the Newark channel at Buckeye Lake. Its head waters received much of the drainage of Madison and eastern Hopewell townships, Muskingum County, and of southern Hopewell Township, Licking County. The course of this channel is located along the site of the present valley of Jonathan Creek as far as the Perry-Muskingum County line where a col formerly existed.[6] Secondary tributaries extended along the sites of what are now

[6]Davis, H. J., Modifications in the Jonathan Creek Drainage Basin. Bull. Denison University, Vol. XI (1899), pp. 164–175.

Painters Run, Turkey Run, and Valley Run in Madison and Hopewell townships. Little data on the thickness of the drift can be secured in this region. However, well No. 1 situated on the Fred S. Mechling property at Yost in Section 5, Hopewell Township, Perry County, and located near the center of the old channel, penetrated 207 feet of drift before reaching bed rock. At the John Yost No. 1 well near Thornville Station the thickness of the drift is about 290 feet and the elevation of bed rock is about 615 feet above tide. The course of the old valley apparently paralleled the southern shore of the eastern half of Buckeye Lake, meeting the Newark channel near the western end of the lake.

A third valley of less extent is followed closely by the present valleys of Swamp Run and Claylick Creek from eastern Franklin Township, Licking County, as far west as Fleatown where the valley took a southwestern direction joining the axial channel a short distance east of Hebron. Northeast of Fleatown bed rock occurs above the level of the present drainage which in a part of its course flows on a thick deposit of glacial drift. About 112 feet of such material was penetrated before reaching bed rock at the Sina Swisher No. 1 well located about 2 miles above Fleatown, and 187 feet was recorded at the Davis No. 1 well located one-half mile west of Fleatown.

Valleys from the west tributary to that part of the Newark channel located southwest of Newark are not clearly defined as the glacial drift deposits are generally thick and as few deep wells have been drilled. The upper surface of bed rock apparently rises to the northwest from Baltimore, for in the northwestern quarter of Section 12, Liberty Township, only 54 feet of drift were recorded in well No. 1 on the F. P. Miller farm. As the well-head elevation is about 950 feet, the upper surface of bed rock occurs here at an elevation of about 896 feet or some 370 feet above the level of the Newark channel to the east. A large tributary apparently headed in the direction of Pataskala, flowed southeast past Kirkersville, and entered the axial channel near the western end of Buckeye Lake. A deep well drilled along this old channel about 2 miles northeast of Etna and near the southern edge of Harrison Township penetrated 320 feet of drift and struck bed rock at an elevation of about 645 feet. A second deep well located about 1¼ miles east of Etna reached rock at a depth of 183 feet or at an elevation of about 850 feet. The drift is generally

thick in the northwestern part of Union Township, for wells show depths ranging from 230 to 350 feet. Bed rock elevations in this part of the township vary from 620 to 665 feet. The rock surface rises to the north, however, for it reaches heighths of 800 feet or more in the northwestern part of Union Township.

RACCOON VALLEY.

During the Newark stage a deep channel was cut along the site of the present valley of Raccoon Creek at least as far west as Alexandria.[7] The depth of the valley filling is about 220 feet below stream level at Alexandria and about 250 feet at Granville. West of Alexandria the old channel is not clearly defined as well data is lacking. South of Raccoon Creek rock outcrops occur along Moots Run in St. Albans Township, and the upper surface of bed rock extends to or above the level of Raccoon Creek in southwestern Granville Township. Wells drilled along the north slope of the valley penetrated drift ranging in thickness from 45 to 160 feet. At the Andrew Board No. 1 well located one mile northeast of Alexandria bed rock having an elevation of about 1000 feet was reached at a depth of about 40 feet. Bed rock with an elevation of about 960 feet was encountered at a depth of about 160 feet at the Tally No. 1 well situated along the road three-fourths of a mile southeast of St. Albans Church. A third well drilled on the Chas. Guckert property two miles northeast of Granville showed 46 feet of drift with bed rock encountered at an elevation of about 1030 feet. A fourth well on the William Howe farm north of Granville penetrated 63 feet of drift before reaching solid rock which has an elevation at this place of about 970 feet.

NORTH FORK AND ITS TRIBUTARY VALLEYS.

The axial drainage of the Newark system was joined at Newark by a large tributary from the north which had its head waters in northern Knox County. The main channel of this tributary followed closely the site of the present North Fork of the Licking River from the southwestern corner of Morgan Township, Knox County, to its mouth at Newark. For purposes of convenience in this description it will be known as

[7]Scheffel, E. R., Significance of Drainage Changes Near Granville, Ohio. Bull. Denison University, Vol. XIV (1908), pp. 157–174.

the North Fork of the Newark Valley. In Morgan Township the North Fork was formed by the union of two branches, an East Branch which had its head waters in Pike, Brown, and Jefferson townships, Knox County, and a West Branch which headed in Berlin and Middlebury townships and probably received waters from the east-central part of Morrow County.

The North Fork of the Licking River from Morgan Township to its mouth flows on glacial material which varies from 300 to 360 feet in thickness. This excessive thickness of drift represents the amount of filling in the old channel which was much narrower than the present valley. Wells drilled near the margins of the valley flats sometimes show comparatively little drift, while wells more centrally located reach bed rock at much greater depths. Bed rock in the Newark channel near the mouth of North Fork lies some 300 feet below the surface and has an elevation of about 537 feet. At the Frank A. Dusk No. 1 well located west of the center of the valley in southern Newton Township bed rock with an elevation of about 680 feet was reached at a depth of 231 feet. The record of the McKinney well situated near the eastern edge of the valley three-eighths of a mile southeast of Vanatta, shows that 110 feet of drift was penetrated before reaching bed rock which occurs at this place at an elevation of about 730 feet. A third well drilled near the center of the old channel 1½ miles south of St. Louisville reached rock at a depth of 276 feet. The elevation of the upper surface of solid rock at this well is about 605 feet or about 68 feet above the level of the channel at Newark. The record of another well located on the William Weitham farm, a half of a mile east of the mouth of Lake Fork, shows 336 feet of drift with bed rock at a height of 614 feet. At the junction of East Branch and West Branch the upper surface of bed rock occurs at an elevation of about 655 feet, which is 118 feet higher than the level of the old channel at Newark. Based on these figures the average slope of the old channel of North Fork was slightly more than 7 feet per mile to the south.

Leverett examined the valley of North Fork and found low rock hills in the midst of lowlands about 3 miles south of Utica. He concluded therefore, that a divide formerly existed at this place which barred a southward course for the drainage of the region lying to the north. In accordance with Tight's opinion Leverett concluded that the discharge was westward

to the Scioto basin past Homer.[8] The data derived from well logs is not in accordance with Leverett's interpretation. Wells drilled on the present valley flats about 2½ miles south of Utica and therefore a little north of the proposed divide, show the presence of a deep channel as much as 336 feet below the general level of the lowlands. Here the elevation of bed rock, which is about 614 feet, is only about 60 feet higher than it is at Newark and it is lower than at any place in the old channel farther north. These facts point to a southern direction of discharge past Utica to Newark.

West of North Fork many well records in Bennington, Burlington, McKean, Liberty, Granville, and St. Albans townships show that bed rock occurs on the uplands at elevations ranging from 950 to 1150 feet, while east of the valley in Newark, Newton, Washington, and Morgan townships the upper surface of bed rock rises to elevations ranging from 750 to 1050 feet.

Three tributaries of some size entered the North Fork from the east. The first and most northern one of the three had its head waters in southeastern Morgan Township and flowed in a westerly direction past White Oak School. A well drilled along this channel on the Rachel Bell farm one-half mile west of White Oak School struck bed rock at an elevation of about 790 feet after penetrating 212 feet of drift.

A second tributary channel entered the North Fork near St. Louisville. Its valley extended to the northeast through eastern Washington Township along a course now followed closely by a southwestern branch of Rocky Fork. A boring at the Redbrush School penetrated 335 feet of drift before reaching solid rock, while five-eighths of a mile farther west a well having about the same elevation reached rock at a depth of about 178 feet. At the M. J. McClelland No. 1 well located along this old channel about 1½ miles north of Redbrush School rock was reached at a depth of about 280 feet. As the casing-head elevation is about 1025 feet, bed rock at this well has an elevation of about 745 feet. One-half mile northeast of the McClelland well, a test on the M. H. Thrapp farm showed 245 feet of drift with bed rock at an elevation of about 765 feet. To the northwest and southeast of the McClelland and Thrapp wells borings show that bed rock rises to elevations

[8]Leverett, Frank, U. S. Geol. Survey, Mon. XLI (1902), p. 161.

of 1000 feet or more. From the Thrapp well the old channel extends into northwestern Eden Township.

The third tributary from the east entered North Fork in the northern part of Newark Township. It extended to the northeast past Newton Chapel, Wilkins Run, and Hickmon, and had its headwaters in northwestern Perry, southwestern Fallsbury, and eastern Eden townships. Rocky Fork now receives waters from much of the area which formerly drained through this tributary channel. Few wells have been drilled along the course of this old valley and no data on the thickness of the drift is at hand.

Many tributaries entered the North Fork of the Newark Valley from the west but only three are sufficiently well developed to merit much consideration. Two of these tributaries can be traced west to a line extending due north from Alexandria, St. Albans Township. West of this line their course is in doubt as no well data can be secured. Beginning at the north the first large tributary enters the channel of North Fork about one mile north of St. Louisville. This channel was formed about one mile west of Pattons Corners by the union of two tributaries, one from the northwest and the other from the southwest. Southeast of Pattons Corners the course of the old valley is parallel to Lake Fork but lies a little to the south of it. The drift along the course of this valley ranges in thickness from 250 to 400 feet and the elevation of bed rock varies from 615 feet at its mouth to 710 feet in central Bennington Township. On the divide areas to the north and south of this channel the drift rarely exceeds 150 feet in thickness with bed rock occurring at elevations ranging from 950 to 1100 feet. At the D. Myers No. 1 well located in the valley of North Branch about one mile south of the Licking School in Bennington Township, the upper surface of bed rock with an elevation of 715 feet, was reached at a depth of 395 feet. A well drilled along the South Branch about three-fourths of a mile southwest of Beech Knob School penetrated 381 feet of drift before reaching bed rock which at this place has an elevation of about 710 feet. In the region of Fairview School between these branches solid rock occurs at elevations exceeding 900 feet. A half of a mile southeast of Pattons Corners a well located along the main channel of this tributary penetrated 357 feet of drift striking bed rock at about 640 feet above sea level.

The second tributary from the west apparently extended from the central part of Liberty Township to the channel of North Fork near the present site of Vanatta. The Clear Fork of the Licking River follows very closely the course of this old valley. Well records show the elevation of bed rock near Hancock School to be about 920 feet or approximately 300 feet below the surface. Within one mile north or south of this location the upper surface of bed rock rises over 100 feet. One-fourth of a mile east of Brooks Corners a well penetrated 272 feet of drift reaching solid rock at an elevation of about 860 feet. Few wells have been drilled along the channel east of Highwater. However, a boring three-fourths of a mile southeast of Blackhawk School on the south side of the present valley passed through 140 feet of drift, reaching bed rock at an elevation of 860 feet. On the highlands to the north and south of the valley the drift is generally much thinner with bed rock occurring at elevations of 1050 to 1150 feet. A well along the south side of the valley in western Newton Township reached bed rock at an elevation of about 825 feet.

The third and smallest tributary from the west apparently headed in northwestern Granville and southwestern McKean townships and took a course to the North Fork along the site of the present valley of Brushy Fork. A well drilled on the Alva Hamilton farm near the headwaters of this tributary in northwestern Granville Township, showed 245 feet of drift overlying rock which stands at an elevation of about 775 feet. A mile east of this location and on the south side of the valley bed rock has an elevation of about 860 feet, while one mile southeast it rises to 1035 feet, and one mile west it has an elevation of about 960 feet. From the bed of this old channel the upper surface of bed rock rises to the north reaching elevations of 1000 to 1200 feet in McKean Township and 1000 feet or more in eastern Granville Township.

EAST BRANCH OF NORTH FORK AND ITS TRIBUTARIES.

From its junction with the West Branch near the mouth of Sycamore Run in Morgan Township, Knox County, the old channel of East Branch can be traced by well borings in a northeasterly direction to the headwaters of Big Run. Here the channel took a more northern direction to the Kokosing Valley along a course lying slightly west of the present valley of Big Run. From the mouth of Big Run the channel of

East Branch extended along the site of the Kokosing Valley to Howard where it continued in a northeasterly direction through the valleys of Jelloway Creek and Dowd Creek to the present Mohican Valley in eastern Jefferson Township. Excessive thicknesses of drift are recorded in the records of wells drilled along this channel. Near the junction of East Branch and West Branch in Morgan Township, the drift has a thickness of about 300 feet while the bed rock elevation is about 655 feet. Surface materials of similar thickness are found along the channel in Morgan and eastern Pleasant townships. The E. L. McMahon No. 1 well situated along Big Run in the northeastern corner of Pleasant Township is probably centrally located with respect to the old channel as it penetrated 228 feet of drift before reaching bed rock at an elevation of about 720 feet. The rock slopes rise abruptly from this old channel, for the upper surface of bed rock stands at elevations of 1000 feet or more in the northwestern corner and the north central part of Morgan Township and also over much of central and western Pleasant Township.

The channel of East Branch apparently extended along the site of the present valley of the Kokosing River from Howard to the mouth of Big Run. Little well data on the depth to bed rock is available in this part of the valley. That it is deeply filled with drift is indicated however, by the record of the Kidruff No. 1 well located at the northern edge of the valley and at the southern edge of Howard Township where bed rock was reached at a depth of 129 feet.

Along the course of Jelloway Creek and Dowd Creek northeast of Howard valley filling in excess of 100 feet in thickness is present, while on the bordering uplands the surficial deposits vary from 25 to 60 feet. At the James A. Greer No. 1 well located near the west edge of the valley in the northeastern corner of Howard Township, rock with an elevation of about 840 feet was encountered at a depth of 121 feet. At the Rila Rabjohn No. 2 well situated in the valley just north of Dowd Run in the southwestern corner of Section 8, Jefferson Township, rock was reached at a depth of 117 feet or at an elevation of about 900 feet. The deep channel is believed to continue northeast of the Rabjohn well past the Pleasant View School at least as far as the Mohican River, but well data along this part of its course is not at hand. The average slope of the valley of East Branch from the north edge of Howard Town-

ship to the north edge of Morgan Township is about 13½ feet per mile. From the latter point where a large tributary enters from the east to its junction with the West Branch, the valley slopes to the southwest at a rate slighlty in excess of 5 feet per mile.

Valleys tributary to the East Branch were numerous but data on the amount of filling is somewhat meager. The largest tributary entered East Branch from the east through northeastern Morgan Township and northern Clay Township. It received the waters of Harrods Run and had its head waters in the area now drained by Wakatomika Creek east of Bladensburg. A well drilled in this channel on the E. Rinehart property near the eastern edge of Morgan Township penetrated 318 feet of drift reaching bed rock at an elevation of about 680 feet.

A tributary entered East Branch from the northwest near the present mouth of Big Run. This tributary received the waters of Wolf Run and flowed in a southeasterly direction along the present course of the Kokosing valley to the channel of East Branch. A well drilled on the river bank just west of Kenyon College penetrated 40 feet of drift before reaching bed rock. Two miles west of Gambier the Kokosing River flows in a rock-bound channel.

A second tributary from the northwest had its head waters in central Pike Township and followed a course to the southeast along the valleys of Little Schenck Creek and Schenck Creek, joining East Branch in the southwestern part of Howard Township. No well data on the thickness of valley filling is at hand. A third tributary from the northwest followed the site of Little Jelloway Creek from eastern Pike Township, meeting the East Branch near the present mouth of Schenck Creek. The lower part of this tributary valley contains an excessive thickness of glacial material as shown by the record of the N. H. White No. 1 well located in the old channel one mile east of Fairview School where 184 feet of drift is found. A second well is located near the present stream level on the T. J. Porter farm, five-eighths of a mile south of the north boundary of Howard Township, passed through 83 feet of drift material before reaching bed rock. On the uplands both east and west of this location well records show less than 60 feet of glacial material.

In the southeastern part of Brown Township the East Branch was joined by a tributary which headed along its

northern boundary and flowed southward along the site of Jelloway Creek, but in a channel much deeper than the present valley. It was joined by a tributary from the west which had its head waters near Cottage Hill School, and also by a tributary from the northeast which flowed along the site of Hadley Valley. Definite data on the thickness of the drift is likewise meager along the course of these tributary channels. Leveritt reports that flowing water wells 40 feet in depth have been secured in the drift in the valley at Jelloway.[9] Very little glacial drift is present on the uplands in this vicinity.

A drift filled channel extends from Brinkhaven southwest past Danville, meeting the present valley of Jelloway Creek in the eastern part of Howard Township. This channel was evidently a tributary to the East Branch of the North Fork of the Newark Valley. Leveritt cites a well drilled to a depth of 136 feet at Danville without striking bed rock.[10] As the major part of the town has an elevation ranging from 1,000 to 1,040 feet, bed rock at this place can not be much above 900 feet elevation and is probably somewhat below this level. Oil wells drilled about one mile northwest of Danville struck solid rock at or above elevations of 1,050 feet. The topography suggests that this deep channel was joined at Danville by two tributaries, one from the northeast and the other from the southeast. The first of these tributaries had its head waters near Turkey Ridge School in Jefferson Township and followed a course along the site of the East Branch of Jelloway Creek. A well drilled on the Louis A. Lower farm and located on this channel in the central part of Section 24, reached rock at a depth of 82 feet, while on the hills to the northwest and southeast bed rock lies close to the surface. The second tributary apparently headed in the direction of Flat Ridge School and extended northwest past Buckeye City.

The East Branch was joined below Howard by a tributary from the east which had its head waters in Brush Run in Butler Township. From Zuck the course of this tributary channel extended to the northwest along the valley of the Kokosing River for a distance of about one-half mile. From exposures along the valley at this place there is evidence that a channel now filled with drift formerly extended to the northwest across the neck of land formed by the broad loop to the south of the

[9]Leverett, Frank, U. S. Geol. Survey, Mon. XLI (1902), p. 406.
[10]Idem., p. 401.

present gorge of the Kokosing. The old channel entered the present valley a short distance northwest of the plant of the Millwood Stone Co. and continued along the site of the present channel to the East Branch below Howard. No well data on the thickness of the drift in this tributary valley has been secured. The foregoing conclusions are based on the general thickness of fill in the East Branch near the mouth of the tributary, the direction of flow of Brush Run, and the results of field observations along the gorge of the Kokosing River.

WEST BRANCH OF NORTH FORK AND ITS TRIBUTARIES.

The valley of West Branch of the North Fork of the Newark drainage can be traced by well records with some degree of accuracy from its junction with the East Branch in Morgan Township through eastern Miller and Clinton townships to Mt. Vernon. From here it is believed that the main channel extended to the northwest, passing through the western part of Mt. Vernon in the general direction of the Kokosing River and entered Middlebury Township a short distance west of Fredericktown.

South of Mt. Vernon the valley of the West Branch is filled with drift ranging in thickness at various localities from 260 to 350 feet. The record of the J. W. Campbell well, located in this valley near the northeastern corner of Licking County, shows 329 feet of drift with the upper surface of bed rock at an elevation of about 656 feet. In the Philo Higgins No. 1 well, situated about 1½ miles northwest of the Campbell well, the drift has a thickness of 349 feet and bed rock occurs at an elevation of about 680 feet. The drift has a recorded thickness of 285 feet at the C. A. Lefever No. 1 well, located in this old valley in the southeastern corner of Clinton Township. Near Cherry Hall School the lowest part of the channel is marked by 265 feet of drift lying on bed rock which has an elevation of 745 feet as recorded in the record of Well No. 1 on the W. J. Workman property. On both sides of the valley the surface of bed rock rises rather abruptly to elevations of 900 feet or more on the west and 1,000 feet or more on the east. The average slope of West Branch from Mt. Vernon to its junction with the East Branch is on an average about 11 feet per mile to the south.

Very little drilling for oil or gas has occurred within recent years along the probable course of West Branch northwest of

Mt. Vernon. Leverett reports that a well drilled near the city waterworks and therefore in the old channel of West Branch, penetrated 224 feet of drift before reaching bed rock.[11] As the well head elevation is about 900 feet, bed rock has an elevation of about 766 feet. Rock outcrops occur in the east edge of Fredericktown, but in the western part of town wells obtain water from the drift at depths of about 40 feet. On the hills east of Fredericktown the drift sheet is generally thin. Very little data can be secured relative to the thickness of the drift north of Fredericktown in Middlebury Township. The topography suggests, however, that one channel probably extended to the northwest in the direction of Waterford and a tributary channel to the northeast past Ankertown. A well drilled about one-half mile southeast of Caywood School, Middlebury Township, and near the channel first mentioned, penetrated about 150 feet of drift before reaching bed rock.

The West Branch was joined at Mt. Vernon by a large tributary which entered from the north. This tributary had its head waters in western Pike and eastern Berlin townships and flowed south through the upper part of the valley of Schenck Creek and continued to the south along the site of the valley of Center Run. Thick deposits of glacial material occur along this old valley. About one-half mile southwest of Valley Grove School a well drilled to the Clinton sand near the center of the channel penetrated 226 feet of drift, reaching bed rock at an elevation of about 1,080 feet. Both east and west of this well the upper surface of bed rock rises to heights of 1,000 feet or more above tide or over 150 feet above the bottom of the old channel.

South of Mt. Vernon two tributaries joined West Branch from the west. The first and smaller one entered Miller Township about one mile south of the north boundary and extended from this place in a southeasterly direction past Brandon, joining the channel of West Branch about three-fourths of a mile southwest of Lafayette School. Its course is marked by excessive thicknesses of drift and a comparatively low elevation of the upper surface of bed rock. At the Splinterville School the elevation of the upper surface of bed rock is about 975 feet. At the Miller heirs No. 1 well, one mile due north of the Splinterville School, the elevation of rock is about 975 feet and five-eighths of a mile north of the Miller well it is

[11] Idem., p. 408.

1,040 feet. The Ganet Harris No. 1 well, located along the channel of this tributary five-eighths of a mile northwest of Brandon, showed 260 feet of drift with bed rock at a height of 840 feet above sea level. North and south of the Harris well rock rises to elevations of over 1,000 feet.

The second tributary from the west, which apparently was much the larger of the two, entered the west edge of Miller Township west of Oppossum Street School and followed a course a little south of east past the Vance School. As the slope of this valley to the southeast is small in Miller Township in comparison with other tributaries of this system, it is probable that the valley had its head waters some distance to the west, possibly beyond Blendon Township. A well drilled in this old channel on the Levi Thompson farm, west of Oppossum Street School in Miller Township, penetrated 360 feet of drift before reaching bed rock. A second well near Vance School passed through 324 feet of drift.

The Newark Valley was joined at Hanover by a large tributary from the northeast which apparently had its head waters in Perry Township, Coshocton County, and in Jackson Township, Knox County, and extended along the sites of the Brushy Fork and Wakatomika valleys in Perry and Fallsbury townships, Licking County, and the Winding Fork Valley in Pike and Perry townships, Coshocton County. The topography suggests that a tributary entered this channel from the north along the site of Jug Run in Jackson Township, Knox County, and in Fallsbury Township, Licking County. A second tributary entered from the east along the site of Five-mile Creek in Pike Township, and Wakatomika Creek in northwestern Jackson Township. The old valley floors are now buried beneath thick deposits of glacial outwash. At the Ashcroft well, situated on the side of the valley in Section 21, Fallsbury Township, the drill penetrated 58 feet of drift, reaching bed rock at an elevation of about 742 feet. Records of wells drilled in the old valley at Perryton show alluvial material ranging in thickness from 60 to 160 feet. At the J. E. Seward No. 3 well, located about four-fifths of a mile east of town, the valley filling has a depth of 158 feet, bed rock being reached at an elevation of about 630 feet. No records of the thickness of the drift has been secured southwest of Perryton. Unconsolidated materials also occur in excessive thickness along the eastern tributary in northwestern Jackson Township.

A quarter of a mile west of the Patterson Bridge across Wakatomika Creek, the drill penetrated 99 feet of unconsolidated material before reaching bed rock, while a quarter of a mile southeast of this bridge the record of a well drilled near the center of the present valley shows 40 feet of unconsolidated materials. Wells drilled near Ashcroft Ford also show a great thickness of drift.

SUMMARY AND CONCLUSIONS.

During the Newark stage the drainage of Knox County and the north central part of Licking County discharged to the south into the Newark River through a channel which in Licking County followed closely the site of present North Fork of the Licking River. This channel and its numerous tributaries contain drift deposits of great but varying thickness. Data derived from well borings show no evidence of a divide near Utica, as proposed by Leverett, which would block a southern course for the drainage of Knox County during Newark time.

The divide which marked the rim of the basin of North Fork and its tributaries has not been definitely determined on the west, but it probably passed through western Licking and eastern Morrow counties. On the north it is marked by the highlands which extend across the northern edge of Knox and the southern part of Richland and Ashland Counties, while on the northeast it is represented by Kaylor Ridge in western Knox County and by the high hills of its southern continuation in northwestern Coshocton County. It is believed that this divide crossed the Kokosing Valley near the west edge of Coshocton County.

Through numerous tributary channels now deeply filled with drift the Newark River southwest of Newark received the drainage of southern Licking, northwestern Perry, and northern Fairfield counties. Beyond Baltimore, Fairfield County, the exact location of the Newark channel has not been traced by well borings.

STUDIES OF THE FOOD HABITS OF UTAH LIZARDS.[1]

G. F. KNOWLTON AND M. J. JANES.[2]

During the summer of 1931, 606 lizards were collected principally from desert areas in Tooele and Box Elder Counties, in northern Utah. Most of these were taken on Russian thistle areas near shadscale, sagebrush, or greasewood; most of the collections were made in connection with sugar-beet leafhopper predator studies. Almost the entire food of the lizards consisted of insects, with the addition of some spiders. A much larger number of lizards were examined in 1931 than during the studies carried on during the preceding year.[3]

Most of the lizards were collected with a .22 rifle, using shot shells. After an incision was made in the body cavity, each specimen was preserved in 80 per cent alcohol. The stomach contents were examined microscopically in the laboratory. No attempt was made to identify the large number of insect fragments present in most of the stomachs.

Nearly all of the forms recovered from the lizard stomachs were injurious or of unknown importance. However, beneficial forms, such as *Geocoris decoratus* Uhl. and *Nabis ferus* (L.), predators, and *Pipunculus* sp. parasites upon *Eutettix tenellus* were taken, along with some beneficial Hymenoptera, Diptera and Carabidae.

An analysis of the stomach contents of the two most common forms is given in Table I. Because of the large number of beet leafhoppers consumed,[4] these species are considered as being beneficial in the areas studied.

The stomach contents of the following specimens of the brown-shouldered Uta, *Uta stansburiana stansburiana* (B. and G.), are fairly typical: Specimen (1) collected in a Russian thistle area at Flux (Tooele County), October 19; 3 nymphal *Eutettix tenellus* (Baker), 4 Nysius ericae (Schill.), 1 adult and 1 nymphal *Geocoris decoratus* Uhl., 1 lepidopterous larva and

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[1]Contribution from the Department of Entomology, Utah Agricultural Experiment Station. Approved for publication by Director.

[2]Associate Entomologist and Graduate Assistant, respectively.

[3]Notes on Insect Food of Two Utah Lizards. By G. F. Knowlton and M. J. Janes. *In* Proc. Utah Acad. Sci. 8: 140–142 (1931).

[4]The Beet Leafhopper in Northern Utah. By G. F. Knowlton. Utah Agr. Exp. Sta. Bul. 234 (Tech.), (1932).

1 spider. Specimen (2) collected in a Russian thistle area west of Delle, August 14; 8 adults and 1 nymphal *Eutettix tenellus*, 1 *Geocoris decoratus*, 1 *Pipunculus* sp., 1 *Chloropisca glabra* (Meig.), 5 Formicidae, and 7 spiders. One individual (3) taken on June 19 among *Cheirinia repanda* southeast of Timpie, contained an unusual variety of insects consisting of 1 grasshopper nymph, 3 adults and 1 nymphal *Eutettix tenellus*,

TABLE I.

Stomach Contents of *Uta stansburiana stansburiana* (Baird and Girard) and *Sceloporus graciosus graciosus* (Baird and Girard) Collected on Utah Desert Areas, 1931.

Hexapods (Insects)	Total Stomach Contents of 528 Specimens of *Uta stansburiana stansburiana*		Total Stomach Contents of 61 Specimens of *Sceloporus graciosus graciosus*	
	Adult Insects	Immature Insects	Adult Insects	Immature Insects
Collembola	43	0	0	0
Orthoptera	12	44	3	24
Isoptera	114	0	0	0
Odonata	12	0	0	0
Neuroptera	1	3	0	0
Thysanoptera	4	0	0	0
Homoptera	908	656	61	72
Hemiptera	651	190	41	27
Coleoptera	97	4	25	1
Diptera	337	18	8	1
Lepidoptera	24	57	9	17
Hymenoptera	458	12	215	0
Total Insects	2,661	984	362	142
ARACHNIDA (Spiders)	227 and two masses of eggs.		14	
REPTILIA	1 small *Uta stansburiana stansburiana*.			
FOREIGN MATERIAL	Sand, small pebbles, and plant fragments.			

1 Coreidae, 3 *Nysius ericae*, 3 adults and 2 nymphal *Geocoris decoratus*, 1 Pyrrhocoridae, 1 Reduviidae, 4 Miridae including 3 *Melanotrichus* sp.; 4 Formicidae and 3 Sphecidae. One individual (4) collected under a board among Russian thistle at Delle on October 8 contained 87 termites.

Examples of the stomach contents of the sagebrush swift, *Sceloporus graciosus graciosus* (B. and G.) are: Specimen (1)

collected in sagebrush—Russian thistle area south of Hardup (Box Elder County) July 8; 1 *Eutettix tenellus*, 1 *Thamnotettix venditarius* Ball, 2 Carabidae, 1 Tipulidae, 1 Braconidae, 9 Formicidae including one *Formica fusca* Linn. Individual (2) taken in a Russian thistle—sagebrush area at Showell (Box Elder County), September 7; 2 adults and 7 nymphs of *Eutettix tenellus*, 1 Diptera, 1 lepidopterous larva and 1 Sphecidae.

A larger proportion of ants were found in individuals of these two species during 1931 than among those examined during the preceding year, apparently due to a relative scarcity of other insects.

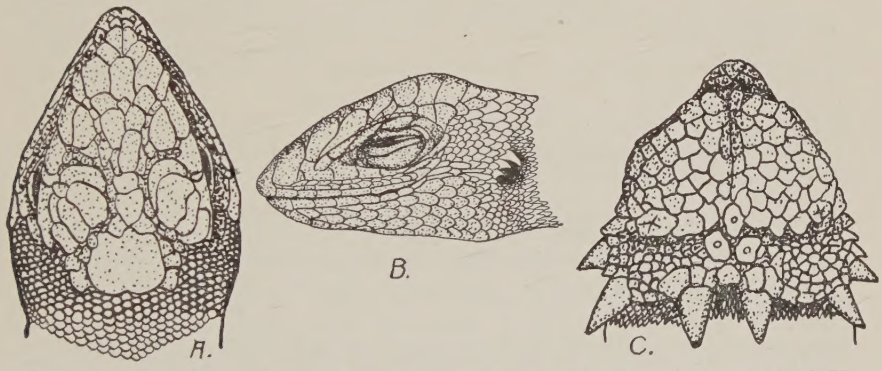

FIG. 1—A and B: Dorsal and lateral views, respectively, of the head of *Uta stansburiana stansburiana* (B. and G.); C: Dorsal view of the head of *Phrynosoma platyrhinos* Girard.

Identifiable insects contained in the stomachs of 528 *Uta stansburiana stansburiana* were:

Order

ORTHOPTERA: Locustidae, 54, including *Trimerotropis vinculata* Scudder 2, *Melanoplus femur-rubrum* (DeGeer) 1; Gryllidae 1.

NEUROPTERA: Chrysopidae, 1.

HOMOPTERA: Membracidae, 10; Cicadellidae, 1,550, including *Agallia sanguinolenta* 55, *Xerophloea viridis* (Fabr.) 1, *Eutettix tenellus* 838 adults and 655 nymphs, *Thamnotettix venditarius* Ball 1; Aphiidae 1.

HEMIPTERA: Pentatomidae, 1; Coreidae, 2; *Lygaeus reclivatus* Say 1, *L. kalmii* Stal 1, *Nysius ericae* 135, *Geocoris decoratus* 386 adults and 155 nymphs; Phyrrhocoridae 1; Reduviidae 1; *Nabis ferus* (L.) 3; Anthocoridae 1; Miridae 151, including *Lygus pratensis* (L.) 134, *Melanotrichus* sp. 3, *Atomoscelis modestus* (Van D.) 5.

COLEOPTERA: Carabidae, 34; Silphidae, 1; Elateridae, 2; Scarabaeidae, 1; Chrysomelidae, 3.

DIPTERA: Culicidae, 1; Stratiomyidae, 1; Tabanidae, 2; Asilidae, 4; *pipunculus* sp., 6; Syrphidae, 1; Tachinidae, 2; Sarcophagidae, 9; Muscidae, 4; *Chloropisca glabra* (Meig.), 99.

HYMENOPTERA: Tenthridinidae, 1; Braconidae, 3; Ichneumonidae, 3; Chalcididae, 26; Formicidoidea, 345; Sphecidae, 5; Dryinidae, 1; Vespidae, 6; Andrenidae, 1; Apidae, 6.

In addition, one large brown-shouldered Uta had swallowed a small individual of the same species.

Identifiable insects contained in the stomachs of 61 *Sceloporus graciosus graciosus:*

ORTHOPTERA: Locustidae, 26; Gryllidae, 1.
NEUROPTERA: Chrysopidae, 1.
HOMOPTERA: Cicadellidae, 127, including *Agallia sanguinolenta* 1, *Eutettix tenellus* 53 adults and 71 nymphs; Aphiidae, 2.
HEMIPTERA: Pentatomidae, 1; Lygaeidae, 41, including *Lygaeus reclivatus* 1, *Nysius ericae* 13, *Geocoris decoratus* 17, *Lygus pratensis* 7.
COLEOPTERA: Carabidae, 3; Coccinellidae, 2; Chrysomellidae, 2; Curculionidae, 1.
DIPTERA: Tipulidae, 1; Sarcophagidae, 1.
HYMENOPTERA: Braconidae, 1; Ichneumonidae, 1; Formicidoidea, 208; Sphecidae, 2; Apidae, 1.

Examination of the stomach contents of nine horned toads, *Phrynosoma douglassii ornatum* (Girard), showed their diet to consist largely of ants; one specimen contained 41, while another possessed 4 ants and 65 ant head capsules. The total for the nine specimens was 161 ants and 157 ant head capsules. Other insects contained were *Trimerotropis vinculata* Scudder 1; *Eutettix tenellus* 1; Carabidae 1; Chrysomelidae 2; Diptera 1; Andrenidae 1.

Stomach contents of six specimens of the horned toad, *Phrynosoma platyrhinos* Girard, consisted mainly of ants. The total insect contents of these was 108 ants and 77 ant head capsules, one specimen possessing 52 individuals. Other insects that had been ingested were *Eutettix tenellus*, 3; Coleoptera, 4, including Coccinellidae 1 and Scarabaeidae, 1; Diptera, 1. The stomach of one specimen contained 5 round worms which apparently were parasitic in the lizard.

A specimen of the desert whiptail lizard, *Cnemidophorus tessellatus* (Say), collected in a greasewood area on the foothills four and one-half miles northwest of Grantsville, May 24, contained 2 Carabidae, 3 larval Elateridae, 1 larval Lepidoptera, and 1 Formicidae.

An individual of *Crotaphytus wislizenii* Baird and Girard taken in sagebrush on the foothills at Hardup, June 24, contained 2 grasshopper nymphs, 1 ant, and numerous insect fragments.

BOOK NOTICES.

Fundamentals of Biology.

This is the second edition of a standard text-book, presenting in a perfectly orthodox manner the basic facts and principles of biology. Little of a controversial nature is touched upon, a fact which makes some of the presentations not strictly up-to-date. For example, no notice is taken of any mechanism of sex-determination other than that of the sex-chromosomes. The list of human hereditary characters is far from modern. Other examples could be mentioned.

The handling of each chapter as a unit, thus facilitating the easy interchange of topics and omission of material on the part of the teacher, is a commendable feature. Many new illustrations have been added. For those who desire a standard orthodox text, the book is quite workable.—L. H. S.

Fundamentals of Biology, by Arthur W. Haupt. x + 403 pp. New York. McGraw-Hill Book Co., 1932.

Botany for College Students.

This is the most recent text to appear in the field of General Botany. Part I, entitled "General Principles," is essentially an elementary treatment of the structures and processes of the seed plants and is a unit discussion in itself. This section is planned for a semester's work in the subject. Part II, planned for a second semester's work and entitled "The Plant Groups," calls the roll of the plant kingdom. The muster is complete. This is essentially a systematic treatment of plant morphology; it adheres closely to the conventional pattern of such presentations. So wide apart are the two sections in point of view and subject matter that each might be regarded as a separate text, but for the fact that both dwell together between the same two covers.

One of the author's reasons for the production of this text is the "evident need of an American textbook which is a general botany in scope as well as in name." Such an assertion treads imperiously into controversial territory. Many botanists would deny this name to a text which is a stranger to all but the names of such vital and dynamic topics as genetics and ecology.

A commendable feature is the wealth of illustrations, practically all of which are original, or especially redrawn for this edition. Almost without exception these are excellent. In addition to the index there is a glossary of the botanical terms used in the body of the text.—B. S. Meyer.

College Botany, by William H. Eyster. 695 pp. New York, Ray Long and Richard R. Smith, 1932.

Hormones and Nerves.

This small book is a most interesting account of the recent and novel hypothesis that the nervous system may secrete hormones which act on muscles, glands, cromatophores and other receptors. The hypothesis is in reality a special application of the general principle of hormones, with the hormones in this case usually traveling very short distances from the point of secretion to that of application. Many interesting recent data are brought to bear on this problem, with careful critical discussions, and the reader cannot fail to be impressed with the intimate connection between hormones and nerves. The author concludes that while "nobody today considers seriously the aphorism that 'the brain secretes thought as the liver secretes bile,' yet if what has been set down in the preceding pages be true, nervous secretion plays a part even in our mental operations such as has scarcely been suspected by the modern physiologist."—L. H. S.

Humoral Agents in Nervous Activity, by G. H. Parker. x + 79 pp. Cambridge Univ. Press (in U. S. A. from The Macmillan Co.). $1.75.

The Evolution of Human Behavior.

Studies of human evolution have of necessity been undertaken largely from the standpoint of man's bodily structure. The present volume is an attempt to approach human evolution from the viewpoint of behavior. The attempt cannot be considered entirely successful since most of the book is given over to discussions of orthodox structural evolution. Nevertheless the result is interesting and somewhat unique. Following a survey of evolution in general, based largely on comparative anatomy, a careful comparison of apes and man is undertaken. Then appears a discussion of the evolution of human culture, based on the author's belief that the differences between man and the apes are mainly cultural rather than biological. Considerable ingenious and plausible speculation is invoked concerning the rise of language and manual dexterity. The differences between present races of man are discussed, largely from a structural viewpoint. The book closes with a chapter on present trends in evolution, including a very sane discussion of eugenics.

The author's speculation occasionally tends to become dogmatic. The statement that "the tri-dactyl foot of the horse is forever lost to the species because of the specialized monodactylism that later evolved" should be compared with Stockard's recent work on dogs. The belief that skin color and similar characters possess no survival value might be open to question. The dogmatic pronouncement that modern warfare is markedly dysgenic is at least a debatable question in the light of recent researches such as those of Gini and Hunt. The author's explanation of heterosis is not the last word on the subject.

The book is, however, a valuable pioneer in the attack on the evolution of human behavior, and as such should be carefully read by every serious student of biology.—L. H. S.

The Evolution of Human Behavior, by Carl J. Warden. ix + 248 pp. New York, The Macmillan Co., 1932. $3.00.

Organic Chemistry.

A text designed for a short course in the theory of Organic Chemistry, together with instructions for a laboratory course to accompany the lectures. The condensation of the general subject of organic chemistry into slightly more than 200 pages, with 60 pages devoted to fats, carbohydrates, proteins and dyes, does not permit much choice of subject to discuss or deviation from the "beaten path" of theoretical organic chemistry. The author presents his subject in the more or less accepted order of saturated hydrocarbons, alcohols, ethers, halogen derivatives, unsaturated hydrocarbons, aldehydes, ketones, acids, fats, dibasic acids, carbohydrates, amines, proteins, cyclic nitrogen derivatives, aromatic hydrocarbons, phenols, acids, aromatic nitrogen derivatives, and dyes; together with 35 pages of laboratory directions covering some 28 experiments in both aromatic and aliphatic chemistry. The laboratory exercises are well selected and should give the student a good technical training in manipulation and an insight into the characteristic aliphatic and aromatic reactions.

The theoretical portion of the text, in spite of the space limitation, is well prepared and in excellent typographical form. There is an absence of tabular material, particularly in the alcohols. In the first part of the book the emphasis has been placed on individual compounds, rather than on class reactions and homologous series; hence there is very little use of functional groups and type reactions (with the use of the symbol R for any alkyl radical). The section on dyes requires, for a proper understanding, a more comprehensive knowledge of organic chemistry than is obtainable in the previous material in the text. The sections on carbohydrates and proteins, while over emphasized, are well prepared and should make the text particularly useful for a short organic course for students in the biological sciences, where such emphasis is to be expected. Another departure from other similar texts is the omission of proper names, both in regard to important theories and discoveries and to reaction names. The use of the laboratory portion of the text is optional, the book being quite suitable for courses without laboratory instruction.—W. R. Brode.

An Introduction to Organic Chemistry, by Ira D. Gerard. vi+296 pp. New York, John Wiley and Sons, 1932. $2.75.